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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS

of a

CONFERENCE ON DENTAL RESEARCH

OTTAWA

13 December, 1944.

Proceedings
of a
CONFERENCE ON DENTAL RESEARCH
Held in Ottawa, 13 December, 1944.

Present:

Dean C. J. Mackenzie, Chairman	National Research Council
Dr. J. B. Collip	National Research Council
Dean E. P. Fotherstonhaugh	National Research Council
Dr. C. H. Best	University of Toronto
Dr. D. Mainland	Dalhousie University
Dr. H. W. Reid	President Elect, Canadian Dental Association
Dr. R. G. Ellis	Chairman, Research Committee, Canadian Dental Association
Dr. H. R. MacLean	University of Alberta
Dr. J. H. Johnson	Canadian Dental Association
Dr. J. F. M. Kennedy	London, Ont.
Dr. D. W. Gullett	Canadian Dental Association
Mr. S. P. Eagleson, Secretary	National Research Council

The conference convened at 2.45 p.m.

Correspondence which has passed between Dr. Ellis, Chairman of the Research Committee of the Canadian Dental Association, and the President of the National Research Council was read. This included a resolution passed by the Canadian Dental Association requesting that the National Research Council establish an associate committee for dental research and provide funds to support the work of the proposed committee.

The Chairman stated that this matter had been considered by the National Research Council at its last meeting and that following full discussion it was the consensus of opinion that it would be desirable to rather definitely define the scope of the activities which it is proposed should be undertaken by an associate committee on dental research, if established, and that consequently the Council had authorized him to convene this conference of those interested in dental research, to meet with representatives of the National Research Council for the purpose of discussing all aspects of this proposal. The Chairman requested that Dr. Ellis open the discussion.

Dr. Ellis distributed a statement entitled, Scientific Research in Dentistry, which was then read and discussed.
(Appendix "A").

The Chairman requested Dr. Best to express his views on the question at issue. Dr. Best expressed the opinion that there is need

for men trained in scientific research to branch into the field of dental research. He felt that the National Research Council is interested in building up personnel suitably trained for dental research, but he stated that he did not recall any graduate in dentistry taking a Ph.D. course with the definite intention of making a career in dental research.

General discussion ensued on ways and means of encouraging suitable dental, medical or other students qualified for a career in dental research.

Dr. Ellis outlined a 5-year programme which had been drafted for the post-graduate training in dental research of a limited number of selected persons, but stated that this plan had not been fully developed, as it had not been found possible as yet to put such a plan into effect.

Dr. Best suggested, and there was general agreement with his view, that the most effective way of developing research workers in the dental, or any other field, was to start with men who have fundamental training in the basic sciences, such as physics, chemistry, etc., and to subsequently interest them in some specialized field of research, such as dentistry, medicine, etc. On the other hand, selected individuals in the dental or medical faculties might be persuaded at a suitable stage of such training to rearrange their course and secure the fundamental training required for a career in dental research.

When the whole question had been fully discussed, it was the consensus of opinion of the meeting that there is need for the encouragement of an increased number of suitably selected students to prepare for a career in dental research, and that the question as to how this could be most effectively accomplished requires further careful study.

The Chairman stated that if an associate committee on dental research were established, the primary interest of the National Research Council would be to ensure that any dental research work undertaken under the auspices of the committee would be well done, and he also expressed the view that the duty of ensuring that those engaged in such work are adequately trained to successfully conduct dental research is crucial.

In this connection Dr. Ellis stated that one of the important considerations leading to the request for the establishment of an associate committee on dental research was the conviction that the existence of such a committee would stimulate an interest in dental research, not only in the profession but would also greatly assist in interesting potential research men in training for a career in dental research.

The Chairman enquired what type of problem the representatives of the dental profession considered should be carried out by an associate committee, if established.

In reply Dr. Ellis presented a list of dental research problems awaiting solution and, in answer to an inquiry from the Chairman, he stated that it is proposed that the associate committee, if established, would award grants to selected persons considered best qualified to investigate an approved problem. (Appendix "B").

The Chairman invited the expression of the views of the Dental Conference as to the functions of a dental committee such as proposed.

In the discussion which followed, the view was expressed that such a committee should take any action which may be practicable to stimulate and coordinate dental research in Canada, and that its activities should be carried on in close collaboration with the Associate Committee on Medical Research, and that the membership of such a committee should not be too large, and should include representatives of the Associate Committee on Medical Research and of fundamental science.

The Chairman inquired as to the views of the dental representatives on the amount of money which would be required if a committee were established. Dr. Ellis stated that no definite estimates had been prepared, but all dental representatives present agreed with his view that such a committee should deal with projects as they arose, and as competent men could be found to direct research thereon, but that initially, and especially under existing conditions, they should start in a modest way financially and develop as circumstances and conditions warrant.

The proposal for the establishment of an Army dental research committee was referred to, and the question as to how the activities of such a committee, if established, should be correlated with those of the civilian committee proposed by the Canadian Dental Association was considered. When the matter had been fully discussed, it was agreed that it is desirable, if found practicable, that there should be only one associate committee on dental research, and it was suggested that if the establishment of an Army dental research committee is considered desirable at the present stage of the war it might be possible to arrange that this should operate as a sub-committee of the associate committee on dental research. Attention was called to the fact that this was the manner in which Service medical committees were initially organized.

It was agreed that the representatives of the dental profession at the conference would immediately discuss with Brigadier F. M. Lott the feasibility of an arrangement such as suggested.

The Chairman expressed the appreciation of the National Research Council to the visiting members of the conference for the contribution which they had made to the deliberations of the meeting and for their kindness in contributing the time necessary to attend the meeting at considerable personal sacrifice.

In reply Dr. Gullette expressed the thanks of the dental

representatives in attendance at the conference for the opportunity which had been afforded them to discuss the questions at issue, and for the very satisfactory manner in which the conference had been conducted.

The conference adjourned at 4:30 p.m.

APPENDIX "A"

Scientific Research in Dentistry

The Research Committee of the Canadian Dental Association has petitioned the National Research Council,

- (1) To establish an Associate Committee for dental research.
- (2) To provide the monies necessary to support the work of the Associate Committee.

It is the considered opinion of the Research Committee of the Canadian Dental Association that it is in the national interests that dental disease, the most universal of all diseases, should be subjected to more intensive and sustained investigation than heretofore.

The need for dental research under the proposed National Health Insurance plans, which include dental benefits, to reduce the incidence of dental disease is obvious. The reduction of dental disease by preventive measures would reduce governmental costs under such a plan. Even a small percentage of reduction in the incidence of dental disease would result in an enormous financial saving. The original cost of the research work would be negligible in comparison with the saving effected.

The dental profession has made a significant contribution to research in the dental field through the work of the Canadian Dental Corps and in the immediate postwar period it is probable that a few unfinished projects will remain to be continued in a peacetime program. Previous to and during the war, civilian research workers in dentistry have made a valuable contribution to the advancement of dental service to the public.

For the above reasons and others which could be enumerated, the national dental organization, namely, the Canadian Dental Association, through its research committee, has submitted its petition for an Associate Committee under the aegis of the National Research Council. In doing so, the following considerations are important:

- (1) Dental research will most likely be initiated by members of the dental profession, and therefore the committee directing such research should have a majority of dental men on it.
- (2) At the present time there is no peacetime committee under the National Research Council which has representatives on it from the dental profession; therefore, the dental viewpoint cannot be expressed.
- (3) The Canadian Dental Association is cognizant of the need for cooperation between various groups of scientists in conducting research and seeks the help of the basic science worker, the biological science worker, and the medical profession.

APPENDIX "B"

Research Problems

1. An evaluation of the factors complicating the correlation between fluorine intake and the incidence of dental caries.
2. Decalcification of dental enamel in Vitro.
3. The effect of various sugars (maltose, lactose, sucrose, galactose) on the rate of lactic acid formation on carious lesions and susceptible areas.
4. An investigation of the mechanism responsible for erosion of dental enamel.
5. The influence of the physical nature of food on the development of the jaws and the effects on the control of malocclusion.
6. An investigation of the cause of pain in cavity preparation, and its control.
7. The effect of heat generated during cavity preparation on the dental pulp. An investigation of various types of abrasives to control the heat.
8. Investigation of the methods of determining the state of vitality of the dental pulp as opposed to a means of indicating the state of the circulation within the pulp.
9. The development of physical or chemical agents to facilitate the removal of calcareous deposits from teeth.
10. The influence of penicillin on dental infections.
11. A determination of the relative efficiency of dry heat and boiling water as sterilizing agents for dental instruments, materials, and oral bacteria.
12. A microscopic study of the effect of dry heat at effective sterilizing temperatures on the crystalline structure, temper and cutting edge of dental burs, broaches, and fine cutting instruments.
13. An evaluation of acrylic resins as used in dental restorations (Polymethyl - Methacrylates) for flow, abrasion, and deformations under stress.
14. A study of the effect of the vacuum investing process on the density of the casting investments used for making dental castings.

15. A study of the agar and alginate impression compounds as to accuracy of reproduction, etc., of an object of variable density.
16. A study of the abrasive qualities of Nylon bristles on dental enamel.
17. Continuation of study of domestic water supplies. Its relationship to dental fluorosis and dental caries.
18. An investigation into the prevalence of dental disease and its relationship to the analysis of soils, vegetables and grains, having regard to nutrients and toxins, mineral depletion of soils, and remineralization.
19. A detailed study, in edentulous mouths, of the effects of progressive changes in the vertical dimension on the anatomy of the temporomandibular joint.
20. Classification of edentulous mouths and ridges, including specific related anatomy, variations of tissue types covering ridges, location and variation of load-carrying areas.

December 13, 1944.

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
FIRST MEETING
OF THE
ASSOCIATE COMMITTEE ON
DENTAL RESEARCH

OTTAWA

1 JUNE, 1945

NATIONAL RESEARCH COUNCIL

First Meeting of the ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Ottawa, 1 June, 1945.

AGENDA

1. Reading of the authority establishing the Committee and fixing its membership.
2. Welcome and introductory remarks by the President of the National Research Council.
3. Review of the present status of dental research in Canada.
4. Investigations in progress and review of results.
5. Consideration of further dental research projects which should be undertaken in Canada, with the objective of compiling a specific research programme on dental research; decision as to who should direct each project and of estimating the financial assistance required for each project to 31 March next.
6. Consideration of the financial requirements of the Committee for the current fiscal year.
7. Other business.

Proceedings of the First Meeting
of the
ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in Ottawa, 1 June, 1945.

Present: Dr. C.J. Mackenzie, Chairman; Dr. H.K. Box; Dr. E. Charron; Dr. R.G. Ellis; Dr. M.H. Garvin; Dr. H.R. MacLean; Dr. G.D. Stibbs; Brig. F.M. Lott; Col. D.S. Coons; Major W.J. Linghorne; Dr. E.F. Burton; Dr. J.B. Collip; Dr. A.R. Gordon; Surg. Capt. C.H. Best; Dr. O.W. Ellis; W/C. J.W.K. Ferguson; Dr. D. Mainland; Dr. D.L. Thomson; Mr. S.P. Eagleson, Secretary.

The Committee met at 9.30 a.m.

1.
Committee
Appt'd.

The Chairman informed the meeting that the National Research Council at a meeting held 15 December, 1944, had authorized the appointment of an Associate Committee on Dental Research, and that at a meeting held 16 March, 1945, the Council had appointed the membership of the Committee, including representatives of the dental profession, the Canadian Dental Corps, and the basic and medical sciences.

He stated that the Council had also decided that there should be rotation in the membership of the Committee, on the same basis as has been adopted in connection with the Associate Committee on Medical Research. Under this plan, appointments are normally for three years, one-third of the members retiring each year. A retiring member may be appointed for a second term, following which he shall retire from the Committee for at least one year. Representatives of the Canadian Dental Corps, having been appointed members of the Committee ex-officio, will remain members of the Committee for such period as each continues to represent the Dental Corps on the Committee.

The personnel of the Committee and the term for which each member has been initially appointed in order to establish the membership rotation schedule are given in Appendix "A".

2.
Members
welcomed

On behalf of the National Research Council, Dr. Mackenzie welcomed the members to the first meeting of the Committee, and outlined for the information of the Committee the policy and procedure of the Council with respect to its Associate Committees, including the respective responsibilities of the Council and the Committee. (see Exhibit "B")

3.
Funds.

Dr. Ellis called attention to the fact that the necessity for post-graduate training in dental research had been stressed at the previous Conference on Dental Research, but that the Council could not provide funds required in connection with the proposal then submitted in this connection. He suggested that this problem be considered by the Committee.

Dr. Collip stated that the proposal made at the previous conference was for the provision of \$4000. or \$5000. for the training of one man, and pointed out that a proposal of this nature is out of all proportion to the established policy and practice of the Council with respect to post-graduate scholarships.

Considerable discussion ensued on the general question at issue. The Committee was unanimously agreed as to the need for the encouragement of post-graduate training in dental research. The Committee was also agreed that the question of ways and means for accomplishing the desired end is unusually difficult and requires further careful study.

4.
Present
position
of dental
research.

The Chairman requested that each member of the Committee give a brief review of the present status of dental research, and outline any specific investigations now in progress which in his opinion could be brought to the attention of the Committee for consideration.

Dr. Main-
land,
Dalhousie

Dr. Mainland reported on views expressed in discussions that he had held with his colleagues, Dr. W.W. Woodbury (Dean of the Dalhousie Dental Faculty) and Dr. J.S. Bagnall (Secretary of the Faculty). He pointed out that, besides supporting individual projects that were presented to it, the Committee might well consider the initiation of projects, allocating different parts of a project to appropriate investigators in various centres. He quoted from a letter written to him (May 14, 1945) by Dr. Woodbury, of which the following is the gist:

"We will take for granted that Dental Research falls naturally into two parts: (1) materials to be used in Dentistry, (2) the biological or pathological processes or sequences, the consequences of which make Dentistry necessary. While there is no clear cut division between these fields....these remarks may be considered chiefly as having to do with the latter.

It is to be hoped that the Committee will not only stand ready to encourage, financially and otherwise, worthwhile research projects that are referred to it, but will also endeavor to broadly visualize objectives, make

"specific plans for their attainment and in time suggest projects that will help to realize these plans. In the main, three problems face Dentistry, viz. caries, periodontal disease and malocclusion. We know very little about their etiology; hence preventive measures to date are most inadequate. Whether more teeth are lost through caries or periodontal disease is a debatable question. However, caries begins its ravages in very early life, while the onset of periodontal disease is usually much later. This might suggest the wisdom of giving the caries problem priority in the initial deliberations of the Committee, especially as the avowed policy of the profession in the event of a Health Insurance programme is to begin with the mouths of the young.

Both caries and periodontal disease with their systemic implications, whether considered etiologically or with regard to their sequelae, will demand the combined wisdom of all the sciences represented by the members of the Committee. Canadian dentistry is fortunate in the breadth of view implicit in this set-up.

Brash told us years ago that in comparison with caries malocclusion presented 'a problem of much greater and indeed an almost baffling complexity'; but he said in the same connection that the problem of caries is by far the more important, and that probably will be the view of the Committee in its initial stages."

As regards dental caries, Dr. Mainland stated that conversation with Dr. Woodbury and Dr. Bagnall had confirmed his own opinion that, before the Committee undertook any extensive work on this subject, what was needed was a thorough and very critical review of recent work and current opinions. It appeared that at least some of the reviews already published should themselves be subjected to criticism, e.g., by a biochemist, a bacteriologist, and other experts. Dr. Bagnall had recently prepared for his students some notes which would form the nucleus of a good critical review of the caries problem, and it seemed desirable that the Committee should give him an opportunity to expand this work into a comprehensive and thoroughly critical review, in the preparation of which he should be able to enlist the aid of experts in various fields when he came upon articles that required their judgment.

Dr. Mainland stated that this mention of criticism in regard to caries led him to generalize. If it had been customary for a Committee to have a motto he would have liked to see in the motto of the Dental Research Committee two words: "scepticism" and "criticism". To follow that motto might mean that less work would be published under the Committee's auspices than if the standard were lower, but

what would be published would have a greater chance of being first-class work, and that should be the aim of the Committee.

Dr. Box,
Toronto

Dr. Box endorsed the view expressed by Dr. Mainland as to the need for dental research on caries, periodontal disease and malocclusion, and outlined work done in Toronto on caries.

Dr. Mac-
Lean,
Alta.

Dr. MacLean suggested that the Committee concentrate initially on one major project, such as caries. He expressed the view that the achievement of definite progress in connection with a major dental problem would be more effective in stimulating dental research than an attack on a number of projects at the present stage.

Dr.
Garvin,
Man.

Dr. Garvin stated that there is at present no dental school in Manitoba. He expressed the view that there is serious question in his mind as to the advisability of adding fluorine, a definite poison, to drinking water until surveys have been made of areas with fluorine in drinking water, and considerable more information is available as to its effect. He also referred to the question of damage to teeth from excessive gum chewing because of the high quantity of sugar assimilated.

Dr.
Stibbs,
B.S.

Dr. Stibbs stated that there is no Dental Faculty in British Columbia. He pointed out that the previous speakers had dealt with physiological problems. He stated that another type of problem is the materials used in dentistry. He expressed the view that it might be worthwhile for the committee to consider work on the improvement of dental materials such as dental cement, etc.

Dr.
Ellis,
Toronto.

Dr. Ellis gave a brief review of the present status of dental research in Canada. He stated that there is quite a little dental research in progress at the University of Toronto. He suggested that the Committee should study dental disease in general. He was also of the opinion that the Committee would be the proper body to undertake such work as a survey on the effect of fluorine on teeth.

Dr.
Charron,
Montreal

Dr. Charron stated that there is very little dental research in progress at the University of Montreal. Although some members of the staff have tried to carry on such work, they have not made much progress because of the lack of personnel suitably trained in dental research. He expressed the view that the first problem is to train men who could undertake such work and assured the Committee of the full co-operation of the Dental Faculty at the University of Montreal in the work of the Committee.

Dr. Thomson said he felt that the greatest need for research in Dentistry was to increase the number of qualified research workers. A very large part of medical research was carried out by men who had no clinical responsibilities and by scientists without medical degrees; on the other hand there were very few dentists not engaged in private or clinic practice, and few scientists have much interest in or knowledge of dental problems. He hoped that the Associate Committee would not be content, year after year, to scrutinize applications from the few laboratories now engaged in this type of research. The establishment of the Committee, and the knowledge that financial assistance was available, should arouse interest more widely; but the Committee should lose no opportunity of stimulating enthusiasm for dental research. He therefore supported the suggestion made earlier by Dr. Mainland, that the Committee should encourage the preparation of critical reviews of the present status of dental research; such reviews, suitably circulated, might enable laboratory workers to pick out problems in which they could effectively contribute knowledge.

Brig.
Lott,
C.D.C.

Brigadier Lott pointed out that the Canadian Dental Corps have to get on with Service problems. He stated that the question of periodontal disease has been taken up in connection with a nutritional study. He stated that their work has been largely on stores items, such as dental materials and equipment. He expressed the view that there is need for improvement in the field of X-ray equipment and also in the improvement of a denture base.

In the discussion which followed, it was pointed out that the improvement of X-ray equipment is a development problem, and that the most effective procedure would be to make representations direct to those who are responsible for work in the field concerned. On the other hand, the improvement of a denture base is a fundamental research problem.

Col. Coons
C.D.C.

Colonel Coons stated that the work in which he had been engaged was primarily the study of the effects of altitude, acceleration, and deceleration on air crew and the effect on oral tissues. He outlined various projects on which work had been done in this connection.

Maj. Ling-
horne,
C.D.C.

Major Linghorne outlined certain additional work undertaken by the Canadian Dental Corps and particularly referred to the fields of prevention and tropicalization. He submitted a copy of a presentation made in May 1945 to the Ontario Dental Association (Exhibit "C")

General discussion took place on each of the above questions as they arose.

5. The Committee then gave consideration to dental research projects which should be undertaken under its auspices. Research projects presented

Dr. Box submitted the following research project:
"The effects of penicillin in a suitable medium on the flora of deep pockets as revealed by the regular and electron microscopes." A more detailed description will be found in Exhibit "D". Dr. Box estimated that a grant of \$1000. would be required for this project.

Dr. R.G. Ellis submitted the following research projects:

(1) Title - "An investigation of the chemical mechanisms involved in the decrease of dental caries by Florides".

Time - Sept. 1945 - June 1946.

Place - Dept. of Chemistry: University of Toronto
Under direction of Dr. J.J. Rae

Cost	-	Technician's salary	\$300.
		Apparatus	100.
		Chemicals	100.
			<u>\$1000.</u>

(2) Title - Composition of Nitrous Oxide mixtures in Dental Anaesthesia.

(a) Critique of methods employed in estimating water vapour in nitrous oxide.

(b) Efficiency of newer CO₂ absorption reagents in anaesthetic machines.

(c) Development of an accurate method of determining the composition of gas delivered by anaesthetic gas machines.

Cost	-	Assistant (B.A. or equivalent)	\$800.
		Apparatus & supplies	250.
		Cambridge gas analyser, N ₂ O and O	500.
			<u>\$1550.</u>

Brigadier Lott presented the following research projects to be carried out under the auspices of the Canadian Dental Corps

- (1) Title - To improve certain properties of the packing material used by the Canadian Dental Corps in the treatment of periodontal infections.

Considerable success in the treatment of periodontal disease has been achieved by the use of this packing material. However, continued observation has shown that improvements are advisable. For example, a most likely advance is the incorporation of penicillin in the pack.

It is desired to begin a project in this connection to determine the advisability of the addition of penicillin and to improve certain other aspects of the formula.

- (2) Title - To improve certain properties of the acrylic resin denture base and to effect an economy in production.

Denture bases of acrylic resin are inferior in certain properties to commercial objects of approximately the same formula.

The technique is slow and is insufficiently modified from vulcanization procedure to completely adapt it to the requirements of acrylic resin.

It is felt that a study of this subject will result in

- (a) an improvement in the dental properties of the finished denture base.
 - (b) a change in technique that will assist with the above improvement in properties, simplify procedure to such a degree as to permit the employment of less skilled technicians and shorten it to effect an appreciable economy.
- (3) Title - To study the effects of altitude, acceleration and deceleration on oral tissues.

The speed, rapid climbing and driving performance of modern aircraft and high altitude service conditions have brought some unforeseen reactions of oral tissues.

The C.D.C. has done a considerable amount of clinical observation on the effects of such conditions on oral tissues. In some instances, correction treatment has been instituted. However, further investigation is indicated on the following points:

- (a) The effects of nitrogen bubbles in the circulatory system of the pulp.
- (b) The reaction of gingival tissues to low pressure.
- (c) The effect of lowered pressures after recent extractions.
- (d) The effect of dental foci of infection on body functions of air crew with particular attention to general health, air nausea, sight and reflexes.

Research
projects
approved

It was agreed that all of the foregoing projects be approved by the Committee and that the grants indicated in connection with the projects submitted by Dr. Box and Dr. Ellis be approved.

Publication
of papers

During a discussion which took place on various questions of policy and procedure, the question of the publication of papers arising from work under the auspices of the Committee was raised and it was agreed that all such papers would be approved by the executive of the Committee before publication.

6.

W/C Ferguson inquired what action would be taken to inform scientific organizations interested in dental research of the establishment of the Committee. The Chairman pointed out that all organizations actively engaged or directly interested in dental research are supposed to be represented on the Committee.

Dr. Ellis stated that the Canadian Dental Society has a limited amount of funds and is anxious to correlate its activities with those of the Committee. He stated that they will use these funds to do missionary work and to train research workers in dentistry.

It was agreed that the Committee should hold its next meeting about the middle of November.

APPENDIX "A"

National Research Council

Associate Committee on Dental Research

		<u>Term to expire</u>
1. <u>Representing Dental Profession</u>		
Dr. H.K. Box	Research Professor of Periodontology, University of Toronto	31 March/46
Dr. G.D. Stibbs	Member of the Board of the B.C. Dental Association	31 March/46
Dr. H.R. MacLean	Lecturer in Operative Dentistry, Faculty of Dentistry, U of Alta.	31 March/47
Dr. M.H. Garvin	Editor in Chief of the Journal of the Candn Dental Assoc.	31 March/47
Dr. R.G. Ellis	Prof. of Operative Dentistry, Director of the Dental Clinic U of T; Chairman of the Research Com., Candn Dental Assoc.	31 March/48
Dr. E. Charron	Dean of the Faculty of Dental Surgery, University of Montreal	31 March/48
2. <u>Representing the Army Dental Corps (ex officio)</u>		
Brig. F.M. Lott	Director General of Dental Services, Army Dental Corps	
Lt.-Col. G. Franklin	Army Dental Corps	
Maj. W.J. Linghorne	Army Dental Corps	
3. <u>Representing Basic and Medical Sciences</u>		
Dr. E.F. Burton	Professor of Physics & Head of the Dept; Director of the McLennan Laboratory, U of T	31 March/46
Dr. J.B. Collip	Research Prof. of Endocrinology, Director of the Res. Institute of Endocrinology, McGill	31 March/46
Dr. A.R. Gordon	Prof. of Chemistry & Head of the Dept; U. of T.	31 March/47

S/Capt. C.H. Best	Prof. of Physiology, Director & Professor in the Banting & Best Medical Research Dept., University of Toronto.	31 March/47
Dr. D.L. Thompson	Dean of the Faculty of Gradu- ate Studies & Research Prof. of Biochemistry, Chairman of the Dept., McGill.	31 March/47
W/C J.W.K. Ferguson	Assoc. Prof. of Pharmacy & Pharmacology, U of T	31 March/48
Dr. D. Mainland	Prof. of Anatomy, Dalhousie University	31 March/48
Dr. O.W. Ellis	Dept. of Metallurgy, Ontario Research Foundation	31 March/48
Dr. C.J. Mackenzie (ex officio)	President, N.R.C.	

APPENDIX "B"

OUTLINE OF THE POLICY AND PROCEDURE OF THE NATIONAL RESEARCH COUNCIL WITH RESPECT TO ITS ASSOCIATE COMMITTEES

Each such Committee is a Committee of the National Research Council which is responsible for:

- (a) The establishment of the Committee.
- (b) The terms of reference when necessary.
- (c) The appointment of the members of the Committee and the fixing of the period of each appointment.
- (d) The appointment of the Chairman and the Secretary of each Committee.
- (e) The appointment of an Executive Committee when required.
- (f) The approval of the annual budget of the Committee and the provision of a financial allotment for the work of the Committee.

It is the responsibility of each Associate Committee:

- (a) To advise the N.R.C. on all matters, within the field assigned to the Committee, which require action by the Council.
- (b) To be informed as to existing knowledge in the assigned field.
- (c) To determine from time to time what further research projects within the assigned field should be undertaken in Canada.
- (d) To decide where each such research project can best be undertaken and who can best direct the research.
- (e) To determine (usually through a small financial executive committee) the amount of the financial assistance which should be granted for each such project during a fiscal year, keeping the total expenditure within the amount allotted to the Committee by the N.R.C.
- (f) To prepare in advance of each fiscal year, a budget of the financial requirements of the Committee.

EXHIBIT "C"

Presentation to Ontario Dental Association

May 1945.

(Major W.J. Linghorne, C.D.C.)

1. Early in the war, the Canadian Dental Corps found that Vincent's Infection particularly, and periodontal disease generally, were prevalent in the Armed Services to such an extent as to constitute a very definite problem. Also recurrences after treatment were quite common. This is not a new problem to the dental profession and to a dental audience it is unnecessary to enlarge on the detrimental effects on the oral and general health in individuals so afflicted.
2. From the point of view of the general health of the troops, it was a medical, as well as a dental problem. That explains the connection between the Medical Branch, Royal Canadian Air Force, National Research Council, and the Canadian Dental Corps, outlined in the programme. A Medical - Dental Investigation Unit was formed to investigate periodontal disease and its control in the Services. The approach fell under two main headings: Prevention and Treatment. Under 'Prevention' the study of avitaminosis as a predisposing factor was carried on. The object in 'Treatment' was to obtain an effective simplified method suitable under Service conditions. This meant that definite consideration had to be given to the movement of personnel under treatment, as the work was often started by one Dental Officer and completed by another. The question of the time the treatment took, of supplies, and their transportation, was also important. To-day we are attempting to report to the profession the highlights of the work of the Investigation Unit. It will be impossible in the time at our disposal to go into much detail and of necessity much of the work that might be of interest must be left out.
3. A conception of the essential nature of periodontal disease formed the background for both periodontal and nutritional studies. Our plan is to briefly outline this premise, and then show how it was applied to the periodontal and nutritional work.
4. Now the premise:
The health of the supporting tissues of the teeth is dependent on the environmental influences in the mouth and the metabolism of the tissues. The stresses to which the tissues are subjected in mastication is an example of an environmental influence. Exposure in an infected field is another. It is the property of all living matter to respond to its environment in such a way as to be better suited to it. Subjecting the tissues to chemical, physical, and mechanical changes of environment within the capacity of the tissues to respond in a physiological manner, is stimulation -- beyond this it is irritation.

5. A disturbance in metabolism may reduce this capacity of the tissues for physiologic response, thus allowing otherwise normal influences to become abnormal. Continued health then is maintained by a harmonious relationship between environmental influences and tissue response. The factors that produce disturbances in this relationship may be grouped under three main headings:

BACTERIAL , FUNCTIONAL, and METABOLIC.

Periodontal disease may be caused by one or any combination of these factors.

6. Thus DIAGNOSIS is an estimation of the degree of each factor in causing the disease.

7. TREATMENT consists of establishing and maintaining a harmonious relationship between these three factors.

8. PROGNOSIS is an estimation of how well this can be accomplished.

9. The 'Service Treatment' was developed for this purpose and I am going to discuss it under the bacterial, functional, and metabolic headings.

10. The Bacterial Factor:

This is, creating a suitable bacterial environment for the tissues, or, the treatment of the infection angle. Upon consideration I believe you will agree that this eventually boils down to the restoration and maintenance of an intact keratinized, healthy epithelium.

11. It consists of:

(i) Drug therapy.

(ii) Elimination of areas favouring bacterial concentration in contact with the tissues.

(iii) Removal of irritants.

(iv) Stimulation and cleansing.

12. Now drug therapy:

The most common acute periodontal infection in the Services is Vicent's Infection. From the point of view of time, drug therapy in the form of a mouth wash was considered the most suitable for the treatment of the acute symptoms. The

next four pictures illustrate the action of the mouth wash developed for the treatment of Vincent's Infection:

- (i) The first picture shows a typical Vincent's ulcer of the cheek. The first diagnosis of the case, on entering our hospital, was mumps. However, the true cause of the trouble was soon found. The patient was given a bottle of mouth wash with the proper instructions for its use, four times per day. Nothing else was done.
- (ii) The picture on the right was taken the next day. Many of the acute symptoms had subsided considerably.
- (iii) The next picture is 24 hours later.
- (iv) The next picture was taken the following day.

The time between the first and last picture was three days. This is typical of the action of the mouth wash in treating the acute symptoms of Vincent's Infection of the periodontal tissues.

13. If there are no acute symptoms we start at the second step. Elimination of areas favouring bacterial concentrations in contact with the tissues. This is the most effective method of combatting bacterial activity in periodontal disease. Periodontal pockets, flaps over wisdom teeth, and unhygienic restorations, comprise the bulk of these areas. For the reduction of the periodontal pocket the service method of choice is the use of a displacement pack, although in some cases gingivectomy is used. The method of using the pack is illustrated by the next five sketches.

14. In FIGURE 'A'

We have a periodontal pocket requiring elimination. Pressure from a pack without first packing well down into the pocket would just compress the tissues.

Figure "B" shows the first portion of packing in place. Note the partial displacement of tissue.

In Figure "C" we see the final roll of pack in place. The arrow indicates the direction of light finger pressure.

Figure "D" shows the position of the tissue following finger pressure towards the gingival.

Figure "E" illustrates the desired result following removal of pack.

The next two pictures show the result in the mouth. It was found that by adding a certain kind of asbestos fibre to the well known zinc oxide, resin, tannic acid base when mixed with eugenol produced a material which had the necessary properties for a displacement pack.

The next stage is the removal of irritants such as is caused by calculus, faulty contacts and restorations. After the pack is used much of the calculus which has been sub-gingival is now supra-gingival. You can see that the scaling and polishing procedures are facilitated in this mouth than where the mouth was in this condition.

The next stage is the institution of measures for stimulation and the maintenance of oral hygiene. In the services this is accomplished by the use of Stim-U-Dents and a suitable tooth brush technique.

The following before and after treatment pictures illustrate the result of this bacterial treatment. All cases were treated in one week and the pictures taken the next. They had either two or three dental appointments, each of approximately one hour.

Now the Functional Factor

The objective in treatment is to provide the functional stimulation necessary for the maximum development and health of the tissue, but within the capacity of the tissues to respond physiologically; beyond that is trauma. The more one studies this functional factor the more one realizes its tremendous importance in the long range view in the health of the masticatory apparatus. In a healthy individual whose periodontal tissues are receiving correct functional stimulation, a reserve over the functional requirements **is developed**. It is this reserve that permits variations in the functional and metabolic factors without loss of health. Also it is this reserve that the Dentist depends on when he increases the function of a tooth when it is used as an abutment or for a clasp. If there is no reserve the additional load disturbs the balance and break-down occurs. Individuals with incorrect functional stimulation of the periodontal structure, develop little or no reserve with the result that minor variations of either the functional or the metabolic factor may result in breakdown. It is our belief that the abnormal function present in most of our patients mouths is a big factor in causing the gradual break-down that is so common as to be considered almost normal.

The method used in the Services requires a minimum amount of tooth grinding by the dentist and the use of a chewable abrasive by the patient. It is based on two principles;

1. Increasing the area that sustains the force
2. Increasing the time interval of its application

For example, if an egg is dropped on a hard wood floor from a height of three feet it would probably break. If it were dropped from the same height in loose sand it probably would

not break. The force generated is the same, but the egg does not break because: first the area supporting the force is increased and second the time interval of its application is also increased. The application of these principles to occlusal adjustment boils down to changing the mastication action from a more or less vertical crushing action; where the force is sustained suddenly as when the egg is dropped on a hard wood floor to a grinding or triturating action where the force is sustained as when the egg is dropped in sand. In consultation with a physicist at the National Research Council I was amazed at his statement that making this change may reduce the resultant force on the tissue to as much as 100 times. The technique developed for applying these principles in occlusal adjustment is being forwarded to the Journal of the Canadian Dental Association for publication at an early date.

Now the Metabolic Factor

The metabolic refers to disturbances in the metabolism of the tissues with particular reference to the maintenance procedures. If there is an interference in the supplies to the tissues of the essential materials for good metabolism or the disposal of waste products, sufficient to adversely affect the maintenance procedures, it may result in a disturbance of the harmonious balance between the environmental influence and maintenance procedures. Disturbances such as diabetes, malnutrition, blood dyscrasias adversely affect the maintenance procedures. There are probably many lesser non-specific factors that also affect maintenance. The following three points are offered as an aid to the clinician in detecting the presence of an adverse metabolic factor:

1. A pathological reaction of the periodontal tissues more severe than can be accounted for by the functional and bacterial factors.
2. Poor responses to the treatment of these two factors.
3. The recognition of oral manifestations of systemic diseases.

Further information regarding the metabolic factor may often be obtained from the case history and, from consultation with the patient's physician. Having considered these points, an evaluation of the metabolic factor should be made. This evaluation influences the local therapy. For example in a patient with a lowered metabolic factor the harmonious relationship between function and maintenance may often be obtained by reducing the occlusal stress, or again, strict oral hygiene and soft tissue stimulation may compensate for a lowered resistance to oral infection.

In conclusion the approach to the problem of diagnosis and treatment of periodontal disease based on the classification of the etiological factors under the three headings:

Bacterial
Functional and
Metabolic

has been used by many dentists in the Service. It seems to be practical under Service conditions. A paper describing the treatment and technics suggested, is to be sent at an early date to the editor of the Canadian Dental Journal.

EXHIBIT "D"

Study No.

The study of the use of Penicillin in the treatment of periodontal infections.

Periodontal infections may be roughly divided into acute and chronic types. The acute condition most commonly encountered in the Services is necrotic periodontitis (Vincent's Infection). Chemotherapy has for years been useful in the treatment of the acute symptoms.

The C.D.C. has been using an Arsenical mouth wash for this purpose. Penicillin may be more useful in this.

Scope

- (a) To investigate the most suitable form in which penicillin may be used, with due regard to storage, transportation and issue under Service conditions.
- (b) For the treatment of chronic periodontitis or acute types after the acute phase has been treated by chemotherapy, a displacement pack is used. The use of this material also enables the penicillin to reach the bacteria in the bottom of the pockets. It is therefore desirable to combine the two by incorporating the penicillin in the pack.

CONFIDENTIAL

COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
SECOND MEETING
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

23 OCTOBER, 1945

REVISED COPY

(Appendix A was inadvertently omitted from the copy previously dispatched.)

Proceedings of the Second Meeting
of the
ASSOCIATE COMMITTEE ON DENTAL RESEARCH
Held in the Council Chamber
National Research Building
23 October 1945.

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. H. K. Box
Dr. E. F. Burton
Dr. E. Charron
Col. D. S. Coons
Dr. O.W. Ellis
Dr. J.K.W. Ferguson
Dr. M. H. Garvin
Dr. A. R. Gordon
Major W. J. Linghorne
Brig. F. M. Lott
Dr. C. J. Mackenzie
Dr. H. R. MacLean
Dr. D. Mainland
Dr. G. D. Stibbs
Dr. D. L. Thomson
Mr. S. J. Cook, Secretary

2. Chairman's Remarks

THE CHAIRMAN said that following the First Meeting of the Committee several projects had been undertaken and it was hoped to have reports on the progress of these investigations presented at this Meeting. He also announced that Mr. S.J. Cook, of the National Research Council had been appointed by the President to serve as Secretary of the Committee. He expressed regret that Surg. Capt. Best was unable to be present as he had previously arranged to attend an important meeting on Shock and Blood Substitutes.

3. Minutes of the First Meeting

The proceedings of the First Meeting having been circulated, it was moved by Dr. Mainland and seconded by Dr. Stibbs:

That the proceedings be approved as distributed. **AGREED**

4. Business arising from the Minutes

(i) Appointment of Executive

THE CHAIRMAN said that at the First Meeting it had been agreed that all papers arising from work under the auspices of the Committee were to be approved by the Executive before publication. This raised the question as to the appointment of an Executive. He asked the advice of President Mackenzie.

PRESIDENT MACKENZIE said that the appointment of a small Executive would probably prove to be convenient as a means of transacting urgent business between Meetings. Such a group would deal with administrative matters only and he thought the Executive should be small.

THE CHAIRMAN expressed the view that the duties of an Executive would be to deal with matters of an emergency character and to make recommendations regarding financial matters. He suggested that proceedings of the Executive and notices of all meetings of the Executive should be sent to all members of the Committee and that any members of the Committee who might happen to be at the place of meeting when the Executive is called together should feel quite free to attend such meetings.

After a brief discussion it was moved by Dr. Gordon seconded by Dr. Mainland:

That the Chairman appoint the Executive and that the duties of the Executive be as outlined by the Chairman. **CARRIED.**

(ii) Publications Committee

THE CHAIRMAN asked whether it would be considered desirable to appoint a small group as a Publications Committee whose duty it would be to examine all papers prepared for publication before authorization was given by the Committee for their release. The subject was discussed fully, Dr. Mainland pointing out that such a group might not always be competent to deal with every type of paper that might be presented. He suggested that the Executive be given authority to choose reviewers to examine

papers as received. Dr. Ferguson pointed out that it was an advantage to the Committee to have a screening authority pass upon all papers in order that the interest of the Committee might be safeguarded at all times. The President pointed out that there might be two types of publications, one issued under authority of the Committee and the other, scientific papers prepared by individual members and based on work which they had done for the Committee. In the one case the Committee would be definitely responsible for the material contained in the publication while in the other case it would only be necessary to ensure that no material was being published by a member of the Committee until such time as it was agreed that such information might be released. It was noted in the discussion that the examination of papers would not be along editorial lines but rather from the point of view of policy and protection of the Committee's interest.

It was finally agreed to leave this matter to the discretion of the Executive as provided in Minute 5 of the proceedings of the First Meeting.

DR. BURTON asked whether the Journal of the Canadian Dental Association would be a suitable medium for the publication of papers arising from work of the Committee.

DR. GARVIN, Editor of the Journal, replied that he would be very glad indeed to receive papers based on work done under the auspices of the Committee and he said that he was very pleased to note that it had been decided to have the Executive pass upon all papers on Committee work before permitting them to be submitted for publication. //

5. Progress Reports on Approved Projects

(i) DR 1 - "An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides" Dr. J.J. Rae.

DR. GORDON reported briefly that Dr. Rae had begun work under this project in continuation of investigations that he had been carrying on prior to the formation of the Committee. He said that Dr. Rae was at present publishing a paper based on his earlier work on this subject. Dr. Rae had demonstrated reversible exchange in fluoride and was interested in the attainment of the rate of equilibria. He said the fluoride combination was not entirely reversible but was partially so.

DR. BOX said that new ideas of protection against dental caries had arisen in the Faculty of Dentistry, University of Toronto. It had been found that teeth could be protected in a lactic acid solution of pH4.0 if a pinch of phytin, or casein were added. As sodium fluoride also protects enamel against acid attack, Dr. Rae wanted to study the mechanism involved, and this had led to the present investigation.

PRESIDENT MACKENZIE said that he thought this was an excellent example of the way in which the Dental Committee might carry out investigations. In this case the Committee was not claiming full credit for the work that was being carried on but it was serving as a coordinating agent in bringing the project into focus and offering such assistance as might be required to carry it out satisfactorily. He suggested that at future Meetings it might be useful to bring the research workers who are carrying out the studies to make their own reports to the Committee. He thought the Meetings of the Associate Committee on Dental Research should be professional sessions and that the Executive should handle administrative matters. He thought it was very important that care should be taken in the selection of types of projects to be sponsored by the Committee.

(ii) DR 2 - "Composition of Nitrous Oxide Mixtures in dental Anaesthesia", Dr. G.H. Lucas.

DR. FERGUSON reported that Dr. Lucas had been fortunate in securing the services of Dr. Tickle to do the analyses of water and of gas delivered by gas machines. No results of the investigation were available as yet.

DR. GORDON inquired whether any success had been secured using the Carl Fischer method.

DR. FERGUSON did not think so but said that Dr. Lucas had been in touch with the Cambridge Instrument Company regarding the making up of an instrument for thermal measurement. He said Dr. Lucas was trying several different methods of measuring the moisture content of gases. He said the presence of moisture in the gas is a rather serious item as the moisture freezes and tends to block the gas outlet.

DR. GORDON observed that the requirement in the British Pharmacopoeia for the moisture content of gas specifies the use of phosphorus pentoxide in the determination of moisture but that adequate test methods are not available.

THE CHAIRMAN said that he thought the development of an accurate method of determining the composition of gas

delivered by anaesthetic gas machines was the most important item in the investigation.

DR. FERGUSON added that in general manufacturers have overcome the difficulty of drying of gas but the regulations dealing with this subject are not satisfactory.

BRIG. LOTT reported that the C.D.C. does not use gas machines.

(iii) DR 3 - "The Effects of penicillin in a suitable medium on the flora of deep pockets as revealed by the regular and electron microscopes"
Dr. H.K. Box

DR. BOX said it was too early as yet to report on this investigation but he thought some observations on the work leading up to this study would be of interest. The first conception of the use of the displacement pack was that of Dr. Dunlop who was born in Orillia, Ontario and practised in New York City. Dr. Box said that he had used the Dunlop pack for ten years. Then in 1942 he himself had brought out a new formula which was a modification of the Kaiser-Kirkland surgical dressing. This is a germicidal pack. There were two problems to be dealt with, first to get rid of the organisms in the pocket, and second to keep up the process in order to take care of organisms or spores in the necrotic tissues. The most difficult pockets to deal with were those in which there was no visible pus but in which necrosis was taking place. He had found that by putting his germicidal pack into the pocket gently he was able to obtain satisfactory results. The ordinary displacement pack which separates the tissues does not give the same results in these conditions as the germicidal pack.

MAJOR LINGHORNE agreed with the views expressed by Dr. Box and said that it was important to develop satisfactory techniques for specific clinical situations. There had been great improvement in the treatment of periodontal disease in recent years through the use of packing materials.

DR. GARVIN mentioned that an article by Capt. Moore, Canadian Cental Corps, refers to the use of penicillin in packs. He questioned whether penicillin should be included in the pack or placed around the tooth.

DR. BOX said that he had done 145 smears, in cooperation with Dr. Philip Greey, of pockets using penicillin agar pastilles and packs. They had found that penicillin would reach areas away from the packs. Penicillin was not used in the germicidal pack as eugenol destroys it. He said that failure of crevice sterilization in the first series of

treatments is the main cause of recurrence in necrotic gingivitis. In a brief review of the history of this work he said that in 1908 Buest had described and named a peculiar organism found in soft deposits on teeth. In 1929, Buest had reported on further work on fusiform organisms and in 1932 Aisenberg of Baltimore published a paper largely dealing with the stem of Buest's organism. Later the Deans of the University of Tennessee made cultures from lesions of necrotic gingivitis. Dr. Box stated that fusiform organisms are found at the bottom of pockets. Prior to scaling and extraction a pack is needed to eliminate these organisms.

- (iv) DR 4 - "To improve certain properties of the packing material used by the Canadian Dental Corps in the treatment of periodontal disease"
Major W. J. Linghorne.

MAJOR LINGHORNE reported as follows:- "Activity of this project has been carried on in collaboration with Dr. D. F. Stedman of the National Research Council.

The results from pack therapy are such that it is felt it will have an increasingly important place in the treatment of periodontal disease.

Preliminary work to date indicates the desirability of enlarging the project to develop suitable materials and a technique for a germicidal pack in addition to the displacement pack.

A plan is proceeding for a cooperative effort in affiliation with a research wing in process of formation in the Periodontology Department of the Faculty of Dentistry of the University of Toronto.

No grant is regarded as necessary at this time."

Amplifying the foregoing report Major Linghorne said that the Canadian Dental Corps uses a displacement pack chiefly. A germicidal pack has its place in Service therapeutics. Development was proceeding on a clinical basis. He thought the project should be reviewed in relation to the bacteriology and pathology involved. Most of his work with Dr. Stedman had been towards the improvement of physical characteristics of the pack. A displacement pack, he explained, is used to eliminate areas where absorption of toxins, and bacterial entry occur, while a germicidal pack is intended to maintain chemotherapeutic materials close to the areas affected, for a definite time. These are also of value in helping to sterilize areas before extraction takes place.

MAJOR LINGHORNE explained that this project might eventually require some financial support from the Committee. At present only Service personnel are being used in connection with this work. Major Linghorne said that he expected shortly to join the research staff of the Faculty of Dentistry, University of Toronto.

THE CHAIRMAN suggested that Major Linghorne work out the details of his project for the information of the Committee. It appeared that it might very well be sponsored by the Service, the Dental Faculty, and the Committee as a combined project.

It was moved by Dr. Charron and seconded by Dr. Mainland:

That the Committee approves in principle the collaborated project proposed by Major Linghorne in which the Canadian Dental Corps, the Banting Institute, the Dental College at the University of Toronto, and the Committee may be concerned and authorizes the Executive to make any grant that may be required on the part of the Committee for the conduct of this project during the coming fiscal year. CARRIED.

(v) DR 5 - "To improve certain properties of the acrylic resin denture base and to effect an economy in denture production", Major R.L. Twible

BRIG. LOTT presented the following report on this subject:-
"Activity in this project to date has been in collaboration with the Ontario Research Foundation.

A considerable amount of preliminary work by the two groups has resulted in the completion of the attached monograph, No. 4501, by Drs. Westman and Schierholtz of the Ontario Research Foundation. (Appendix "A")

This report presents a proposed program for the investigation of advantages and disadvantages of the present resins on issue to C.D.C. laboratories, for the subsequent improvement of the material and the process of the denture construction, and for the possible extension of the study to other materials and processes."

BRIG. LOTT presented a letter written to him under date 18 October by DR. H. B. Speakman, Director Ontario Research Foundation with which there was submitted

a yearly budget for dental research on the project noted above. The total estimated cost for this research without an assistant was \$572.50 per month and with an assistant \$722.50. It was recommended in Dr. Speakman's letter that the Committee be asked to budget for this work on the basis of approximately \$400. per month to cover the direct expenditures involved and that the Ontario Research Foundation be responsible for overhead and depreciation.

Considerable discussion ensued as to the financial relations between the National Research Council as represented by the Associate Committee on Dental Research on the one hand and the Ontario Research Foundation on the other in the prosecution of Dental Research. It was agreed that the problem presented was one in which the Committee would be fully justified in taking an active part.

PRESIDENT MACKENZIE outlined the procedure followed by the National Research Council in dealing with industrial problems in which a charge is made for overhead expense. On the other hand in its relations with universities the National Research Council seeks to collaborate and often assists in the financing of projects by paying the necessary salaries rather than by the purchase of equipment.

DR. O. W. ELLIS said that the presentation had been made on the application in such a way as to indicate clearly the total cost involved and the proposed allocation of expenses between the two organizations to cover the cost of the research. It was agreed that the Ontario Research Foundation had a right to expect that it would be treated somewhat differently from the way in which the National Research Council treats the universities because of the fact that the Ontario Research Foundation's plan of organization demands that it proceed along semi-commercial line.

On further discussion it was suggested by Dr. O.W. Ellis that it might be advantageous for him to review this discussion with the Director of the Ontario Research Foundation to ascertain whether a more satisfactory basis might not be reached in dealing with this problem.

It was moved by Dr. Burton and seconded by Dr. Gordon:-

That the application by Major R. L. Twible be tentatively approved pending receipt of a revised budget. CARRIED.

X (vi) DR 6 - "To study the effects of Altitude, Acceleration and Deceleration on Oral Tissues" Col. D. S. Coons. ,

COL. COONS reported as follows:- "The initial planning on this project involved a review of current investigations on this problem.

In addition, a visit was made by an officer from C.D.C. Headquarters to the Chicago College of Dental Surgery, Loyola University and the Faculty of Dentistry Northwestern University. The object was to obtain the available information on section (a) of the project to study the effects of nitrogen bubbles in the circulatory system of the pulp. As it is considered necessary to obtain further information on the work done to date on this subject a definite study has not been outlined.

It was ascertained that a conference on aviation dentistry was held by interested groups in the U.S.A. Minutes of the conference were obtained through the Secretary, Major Knudtson, Headquarters, Army Airforces, Office of Flying Safety and a liaison established for the interchange of information.

The remaining sections of the project (b), (c), and (d) have not yet been outlined but it is planned to carry out the research as far as possible using service facilities. Therefore, a grant is not being requested at this time". (The letters a, b, c, d, refer to the paragraphs regarding this project on page eight in the proceedings of the First Meeting of the Committee.)

DR. GARVIN said that some work on this subject was being reported in the Canadian Dental Association Journal by Dr. Sterritt.

BRIG. LOTT observed that this work of Dr. Sterritt had been done before the Committee was formed.

DR. FERGUSON said he would like to hear of the techniques being employed. He mentioned that some work on this subject had been done by W/C Stewart at Halifax and also by Dr. Sognnaes of the Royal Norwegian Air Force.

COL. COONS said that the work done by Sognnaes had been chiefly on a review of the literature. He said those who were concerned in this work were rather feeling their way before making any definite commitments as to their programme of activity.

This concluded consideration of the projects approved at the First Meeting of the Committee.

7. Finances

THE CHAIRMAN stated that an interim allotment of \$5000. had been made by the National Research Council to the Committee for expenses during the remainder of the year 1945-46. He asked the Secretary to report on the present position of the finances of the Committee.

THE SECRETARY said that of the \$5000. provided in June 1945 \$889.80 had been expended to 30 September 1945, this being the outlay in connection with the travelling expenses incurred in attendance at the conference and the First Meeting. There was now a balance of \$4190.20 against which applications totalling \$3550. had been approved. The net balance was therefore \$640.20 out of which expenses incurred in attendance at this Meeting would have to be met.

THE CHAIRMAN asked President Mackenzie if he would care to speak on this subject.

PRESIDENT MACKENZIE said that provision would be made by the National Research Council for any grants approved by the Committee and for the travelling expenses incurred in attendance at Meetings. He thought a very good start had been made and that it was more important for the Committee to be careful in its selection of projects than for him to provide a lump sum in the way of a grant to the Committee. He gave assurance however, that adequate funds would be provided for approved projects. He pointed out that if the Canadian Dental Corps is willing to sponsor certain projects approved by the Committee no expense to the Committee would be involved. Similarly other organizations might be willing to undertake work on approved projects and at their own expense. The duty of the Committee should be to review the situation, find out where problems can be done, and then to consider where the money is to come from. At the Annual Meeting of the Committee towards the end of the year when most of the applications for 1947 would be reviewed he thought it should be possible to make an estimate of the Committee's financial requirements for that fiscal year.

8. Applications Could Be Summarized

DR. CHARRON suggested that a summary of applications received be submitted to members in advance of Meeting at which such applications were to be considered. He pointed out that if this were done members could come to the Meeting prepared to discuss in detail the various applications submitted.

DR. BURTON said that this could only be done if the final date for the consideration of such applications were set in advance. He observed that it was not unusual for members to submit applications a day or two in advance of the Meeting at which they wish to have them considered leaving no opportunity for the summarization of the application and its distribution to members.

It was moved by Dr. Burton and seconded by Dr. O.W. Ellis:

That applications for grants in aid to be considered at the final Meeting for the present year shall be required to be filed with the Secretary of the Committee not later than 15 January in order that they may be considered at the February Meeting of the Committee and that summaries of all such applications be circulated in advance of the Annual Meeting.

CARRIED.

9. Notification to Dental Schools

It was moved by Dr. Gordon seconded by Dr. MacLean:

That the Deans of the Dental Schools in Canada be informed that applications for grants in aid for 1946-47 will be considered at the February 1946 Meeting of the Associate Committee on Dental Research and that they be asked to bring this fact to the attention of research workers.

CARRIED.

10. Initiation of Projects

DR. MACLEAN inquired whether it would be in order to present subjects for consideration by the Committee with a view of ascertaining whether grants might be approved if applications were made.

THE CHAIRMAN said that he understood this was quite in order and that all members of the Committee and their research associates should feel free to make submissions to the Committee of any projects which in their opinion might warrant support by the Committee. It would then be the duty of the Committee to determine whether a grant should be made and also where the work could best be done.

11. New Applications

- (i) Title: Critical Survey of the Literature on Dental Caries.

Applicant: Dr. J. Stanley Bagnall, Prof. of Dentistry, Dalhousie University.

Amount: \$200.00

DR. MAINLAND said that he had mentioned this research by Dr. Bagnall at the First Meeting of the Committee (1st Mtg.: Min. 4). He said that Dr. Bagnall had been proceeding with this work and that the present application was in fulfilment of the understanding reached at the First Meeting of the Committee that this project would be approved.

It was AGREED that this project be designated DR 7 in the sum of \$200.00 for the present year and APPROVED.

- (ii) Mr. A. S. Fenton, Faculty of Dentistry, University of Toronto.

Correspondence was read from Dean Arnold D. Mason dated 19 October 1945 suggesting that Dental Research might be carried on by Mr. A. S. Fenton through a grant-in-aid from the Associate Committee on Dental Research and stating that the Faculty would be pleased to have this member of the staff undertake any project for which he is qualified. The letter said that Mr. Fenton would be able to give a reasonable amount of time to such work without interfering with his staff duties. Subject of the proposed work was enamel studies.

It was pointed out that it is not usual for the National Research Council to make a grant to a full-time employee of a university to enable him to engage in research. Grants are made for the employment of assistants to senior men to facilitate the conduct of research but in no case is a grant made by way of salary to the grantee.

PRESIDENT MACKENZIE confirmed this understanding.

DR. BOX said that in view of the discussion he would have the subject reconsidered and would make a submission at a later Meeting.

12. Date of Next Meeting

It was AGREED that the next Meeting of the

Committee should be held at the call of the Chair.

DR. GARVIN reminded the members that the Chicago Dental Meeting is to be held on 16 February and that the Meeting of the Associate Committee on Dental Research should not conflict with this date as no doubt some of the members would want to attend the Chicago Meeting.

Meeting adjourned at 1:00 p.m.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Report on Preliminary Investigation of Denture Research and Proposed Program

Denture Research Report No. 4501

1. Preface

At the request of Brigadier F. M. Lott a short memorandum entitled "Ideas on Denture Research" was drawn up on July 25, 1945 and formed the basis for the preliminary discussions of the subject. It was suggested at that time that the writer and Mr. Schierholtz of the Foundation staff should visit the Canadian Dental Corps Training Centre in Toronto in order to study the technique being used at the present time and should then submit a revised program of research incorporating any ideas suggested by this study.

The writer and Mr. Schierholtz visited the Training Centre on August 31, 1945 and were shown the details of the process then in use by Major Twible and Major Shenton, the latter being in immediate charge of denture methods.

The present report gives a brief description of the methods of denture preparation now in use, describes some preliminary experiments suggested by a discussion of present methods with Majors Twible and Shenton and presents a revised program of research.

2. Description of Present Methods

The denture preparation technique in use at the Training Centre had been developed by Major Shenton and was based on rather extensive investigations that he had made. Lucitone polymer (powder) and monomer (liquid), commercial methyl methacrylate resin materials prepared especially for the dental trade, were used, but the procedure followed differed in some important respects from that recommended by the maker of these materials and was found to give much superior results. The most important points of difference

were as follows:

In proportioning the polymer and monomer, the estimated amount of polymer required was placed in a dish and then only enough monomer was added to bring the monomer level to the point where the upper surface of the polymer was completely wetted. This was considerably less monomer than called for in the maker's instructions.

The mixture was set aside for about 30 minutes as directed but packing of the case was started at the stringy stage or somewhat earlier than directed by the manufacturer.

In packing the case, enough mixture to fill the case was put in, covered with wet cellophane and the pressure applied cautiously. The flask was then reopened, more mixture added and the pressure re-applied. This process was repeated about six times. After each pressing, the surface of the denture was noticeably smoother, the flow of the material under pressure apparently producing a better filling of the flask and reducing heterogeneity in the mixture.

After the final pressing, the flask was placed in a water bath, brought up to boiling over a period of about three-quarters of an hour, kept at the boiling point for one hour and then cooled slowly.

It had been found that cracking of the teeth could be avoided by covering them with a thin film of inert material before packing the flask and this was preferred to the polymerization retarding liquid Di-Tol furnished by the manufacturer.

After processing, the dentures were trimmed and polished mechanically.

By following the above procedure, difficulties with excessive shrinkage of the dentures, rough surfaces or blowing up of the material in the flask had been largely eliminated.

It was felt that if further improvement in the manufacture of dentures from methyl methacrylate resins was contemplated, it should be along the following lines.

(1) Avoidance of Repressing. In earlier discussions the writer had gained the impression that it was necessary to repeat the whole packing and processing operation five or six times in order to secure one in which exactly the right amount of mixture was used to just fill the flask completely and this accounts for the proposal of a quality control study under section 1 (a) of the memorandum of July 25, 1945. Actually, what is practised is progressive packing

and pressing, a considerable amount of material being forced out of the flask at each pressing.

This is not as serious a matter but it does increase the time and attention required from the operator and the elimination of repacking would be a welcome improvement provided the dentures produced were as satisfactory.

(2) Faster Curing. When a faster rate of curing is attempted with the present materials the flask may "blow up", presumably by sudden polymerization and volatilization of the monomer.

(3) Elimination of Shrinkage. While the technique described has largely eliminated shrinkage difficulties, there is still a small shrinkage i.e. the denture has to be sprung slightly to make it fit into the flask again, and the elimination of this shrinkage would be desirable.

As an illustration of what might be accomplished by modification of the materials used, it was pointed out that materials obtained from England under the Kallodentine trade name could, after mixing and packing as described above, be processed by plunging the flask directly into boiling water and cooled by putting the flask into cold water without encountering any difficulty with blowing up or shrinkage.

It was pointed out that Lucitone could also be obtained in the form of a jelly-like mixture of polymer and monomer but that this had a limited shelf life even when kept under cold conditions.

Some work had been done with a special type of flask in which pressure could be applied to the polymer-monomer mixture in the flask as a hydraulic type of pressure produced by a piston and a screw. This was called an "injection method" although it was realized that it did not correspond to "injection molding" as applied in industry in which a thermoplastic polymer is injected by pressure into a mold.

The principal objection to this type of flask was the practical difficulty that the dental mechanics would likely break too many flasks since the total pressure that could easily be produced hydraulically between the two parts of the flask was very large.

2. Preliminary Comparison of English and American Materials

An examination of the Kallodentine and Lucitone polymers under the microscope indicated that the Kallodentine polymer particles should pack more closely and therefore require less monomer for saturation and, therefore, develop

less heat on processing. Some preliminary experiments to check this point are reported in (Appendix) to this report. They are not conclusive and the question will require more detailed study. However, it appears likely that closer packing of the polymer particles should be obtainable and give more satisfactory results.

3. Revised Program of Research

I. Present Plastic and Process

(a) Comparison of Lucitone and Kallodentine

Continue this study with a view to elucidating the reported difference between the way in which these materials react to the Shenton technique.

(b) Polymer Particle Packing

Prepare a polymer in such a particle size distribution that it will pack to a high density thus requiring the minimum amount of monomer. Determine by practical trial whether such a polymer is superior to Lucitone.

The preliminary study, (Appendix) indicates that the present polymers pack to somewhat below 50% voids. The maker recommends 9.6 c.c. of liquid to 31 c.c. powder. This should leave 5% air space, yet none is apparent. Further study is indicated.

(c) Study of Present Catalyst and Polymerization Process

The preliminary study, (Appendix) indicates that polymerization once initiated proceeds rapidly and makes temperature control difficult. A study of this process might indicate ways in which a more easily controlled polymerization could be provided.

Parts (a), (b) and (c) would be directed towards the elimination of repressing and the shortening of the processing period.

(d) Shrinkage Compensation or Prevention

Possible means for eliminating shrinkage stresses would be investigated. This would include a study of modified plaster molds, of the maximum

temperature at which the present processed material is capable to withstanding stresses and of the shrinkage of the mold and denture from this temperature to room temperature.

(e) Finishing Study A

A study of solvent vapour methods for the final polishing of dentures and removal of any surface porosity.

(f) Finishing Study B

The production of a surface on the polymer that is wet readily by water and a study of the advantages and disadvantages of such a surface. On theoretical grounds it should provide a more serviceable denture.

(g) Porosity and other Tests

Adaptation of methods such as are used in the examination of optical glass blanks. The denture would be immersed in a liquid of the same refractive index and examined for porosity or other structural defects. The presence of stresses could probably be detected in polarized light, etc.

II. Other Available Plastics

(a) A review of other plastic materials with a view to their evaluation as denture-forming materials. A continuous program would be needed to keep up with developments in this field.

III. Other Processes

(a) A study of the possibility of injection or types of molding other than pressing.

(b) Pressing of a purely thermoplastic material at higher temperatures along the lines of the glass denture research.

TORONTO, Ontario.
October 2, 1945

A.E.R. Westman
Director of Chemical Research.

(Appendix)

Preliminary Experiments

A visit to the C. D. C. Technical Training Centre at 14 Spadina Road, by Dr. Westman and Mr. Schierholtz, during which Major Shenton demonstrated the present procedure for making dentures, suggested a few experiments, the results of which should be valuable in planning a more comprehensive program. Major Shenton pointed out that in working with the American product, Lucitone, it was essential to bring the temperature of the loaded flask up gradually to 212°F, and the cooling operation also had to be done gradually. Otherwise undue deformation or cracking occurred. It seemed desirable to check a few apparent reasons for this difference in behaviour. One possible reason might be that the particle packing of the Lucitone was not as good as that of the Kallodentine, and hence the distribution of the monomer throughout the polymer mass was not as good. This could conceivably lead to local concentrations of exo-thermic heat, causing local strains. Another possible reason was that the catalyst of the respective compounds had different degrees of activity. It was decided to check the above two possibilities.

1. Particle Packing

Examination of the two polymers, at a magnification of 60 diameters, showed that the globules of Kallodentine had a much wider range of diameters than those of Lucitone. This indicated that Kallodentine should pack more densely. Determinations made to check this, yielded the following results.

<u>Determination</u>	<u>Lucitone</u>	<u>Kallodentine</u>
Apparent Specific Gravity	0.761	0.777
True Specific Gravity	1.203	1.212
Apparent Specific Volume	1.314	1.297
True Specific Volume	0.831	0.825
Fraction of Voids in Mass	0.483	0.472

The difference obtained seemed small in view of the microscope examination. On looking at the material more closely, it was noted that a good many of the globules were stuck together in clusters which would prevent them from falling into their natural position on packing. A sample of the Kallodentine was put into the shaking machine with some steel balls. This broke up some of the agglomerates, but not a very large percentage of them. The fraction of voids was now 0.467.

It was now decided to attempt a redistribution of the particle sizes in the Lucitone sample, in the hope of reducing the percentage of voids. If successful, the mix was to be submitted to Major Shenton for a study of the molding behaviour.

Sieve Analysis of Lucitone

1. Retained on 48 mesh	- 22.3%
2. " " 65 "	- 35.6
3. " " 100 "	- 32.0
4. " " 150 "	- 8.0
5. Through 150 "	- 1.5
	<u>99.4</u>

Fractions 1, 4 and 5 were mixed in order to determine the effect on packing. On testing, the fraction of voids was now found to be 0.438, which was some improvement, but still disappointingly large.

Attempts were made to grind a sample of Lucitone at minus 40° to minus 50°C. However the shattering obtained was negligible. The indication was that if any material reduction in voids is to be obtained it will be most conveniently done by sifting fines out of a very large quantity of material, for adding to the coarse in various definite proportions.

II. Relative Activity of Kallodentine and Lucitone

On the theory that some of the difficulties encountered with these materials are due to the rate of polymerization and hence to the rate of liberation of heat, it was decided to run some comparative experiments along these lines.

Experimental Technique

Mixtures of monomer and polymer were made up, by weight and put into 1" x 8" test tubes which were placed in a water-bath. Thermometers were placed in each of the mixes and also in the bath. The bath was now raised at a rate of from 1.5° to 2.0°C per minute, reaching 85°C in about 40 min. All three thermometers were read simultaneously at one minute intervals.

Two experiments were run; the mixes being as noted below.

Results

Experiment 1:

Tube A - Lucitone polymer plus Lucitone monomer

Tube B - Kallodentine polymer plus Kallodentine monomer.

	<u>Tube A</u>	<u>Tube B</u>
First sign of exothermal heat	80.5°C	74°C
Sharp rise of " "	83.5	77.5
Maximum temp. of mixture	139.0	127.0
Increase over bath temp. at max.	53.0	47.5

Experiment 2:

Tube A - Lucitone^{polymer} plus Lucitone monomer.

Tube B - Kallodentine polymer plus Lucitone monomer.

	<u>Tube A</u>	<u>Tube B</u>
First sign of exothermal heat	76°C	78°C
Sharp rise of " "	79	81
Maximum temp. of mixture	142	138
Increase over bath temp. at max.	55	49

Comment

Lucitone mixture requires a higher temperature to initiate the reaction. The mix also reaches a higher maximum temperature. In the case of both mixtures the temperature rises almost instantaneously, once the reaction is started, to the maximum.

Where the Lucitone monomer is used for both mixes, the Kallodentine mix requires a little higher temperature to initiate the reaction. This indicates that the late start of the Lucitone in Experiment I is due to the monomer. In spite of the fact that the reaction of the Kallodentine started at a higher temperature than the Lucitone it did not reach as high a maximum temperature. Also, the rise over the bath temperature at this point was 49°C , i.e. 6° lower than for the Lucitone polymer. This checks with a difference of 5.5°C in Experiment I. This indicates that the Kallodentine polymer reacts less vigorously than the Lucitone polymer.

Since the rate of heating will vary a little from one experiment to another, each experiment should be considered by itself in drawing any comparative conclusions. The results so far obtained indicate that further experiments along similar lines should contribute considerably to an understanding of what is taking place. They should not be considered as final and conclusive because of the limited number of samples tested.

October 2, 1945

O.J. Schierholtz
Research Chemist

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
THIRD MEETING
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

18 FEBRUARY, 1946

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- B - Critique of Methods used in Determining the Water Vapour Content of Nitrous Oxide, by Dr. G.H.W. Lucas and Dr. R.J.S. Tickle.
- C - Report on DR 5 - Denture Base Materials, by Dr. R. L. Twible.
- D - Ontario Research Foundation (Division of Chemical Research) Denture Research Report No. 4502, by D. R. Christie.
- E - Ontario Research Foundation (Division of Chemical Research) Denture Research Report No. 4601, by D. R. Christie.
- F - To Study the Effect of Altitude Acceleration and Deceleration on Oral Tissues, by Col. D. S. Coons.
- G - Report of Project DR 7, by Dr. S. Bagnall.
- H - Memorandum on Project DR 4 by Major W. J. Linghorne.
- I - Map showing Fluorine in Water Supplies in Ontario.
- I-2 - Map showing Fluorspar Deposits of Canada.
- J - Distribution of Fluorine Waters in Alberta, by Dr. H. R. MacLean.

Initial Distribution

Proceedings of the Third Meeting
of the
ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber
National Research Building

9:30 a.m., 18 Feb. 1946

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. E. F. Burton
Dr. E. Charron
Dr. J. B. Collip
Col. D. S. Coons
Dr. O. W. Ellis
Dr. J. K. W. Ferguson
Dr. A. R. Gordon
Major W. J. Linghorne
Dr. H. R. MacLean
Dr. G. D. Stibbs
Dr. D. L. Thomson

Mr. S. J. Cook, Secretary

By invitation

Dr. W. H. Hutton
Dr. G. H. W. Lucas
Dr. J. J. Rae

Apologies for their absence were received from
Dr. C.H. Best, Dr. H.K. Box, Dr. M.H. Garvin and Dr.D. Mainland.

2. Chairman's Remarks

THE CHAIRMAN welcomed the visitors to the Meeting: Dr. Hutton, Medical Officer of Health, Brantford, who had been asked to come because of his interest in fluorine in water supplies; Dr. Lucas and Dr. Rae both of whom have been carrying out research projects under the auspices of the Committee and who had been invited to present the results of their researches.

3. Minutes of the Second Meeting

The Proceedings of the Second Meeting having been circulated were taken as read and APPROVED.

4. Business Arising from the Minutes

(i)(2nd Mtg.: Min. 4(i)) THE CHAIRMAN reported that he had appointed the following to be members of the Executive:

Dr. R. G. Ellis, Chairman
Dr. E. Charron
Dr. D. L. Thomson
Brig. F. M. Lott
Mr. S. J. Cook, Secretary

On motion of Dr. Ferguson seconded by Dr. MacLean this action was APPROVED.

(ii)(2nd Mtg.: Min. 8) THE CHAIRMAN stated that summaries of all applications received for grants-in-aid had been summarized and distributed to the members prior to the Meeting.

(iii)(2nd Mtg.: Min. 9) THE CHAIRMAN stated that the Deans of the Dental Schools in Canada had been informed that applications for grants-in-aid from competent research workers would be welcomed.

(iv)(2nd Mtg.: Min. 4(i)) It was pointed out that Brig. Lott who had been named to be a member of the Executive had now retired from the Dental Corps to accept a private appointment in the United States and that Col. Coons had succeeded him.

It was AGREED that Col. Coons be appointed to replace Brig. Lott as a member of the Executive.

DR. COLLIP asked whether the Dental Corps needed as many representatives on the Committee in peacetime as it had in war. After some discussion it was AGREED that two representatives from the Dental Corps would be adequate and that in the event of the retirement of any present representatives of the Dental Corps, the Director General of Dental Services would be asked to nominate replacements. At the suggestion of Col. Coons it was AGREED that the second member nominated by the Dental Corps might be from the Reserve of Officers or the Active Army as desired by the Dental Corps.

5. Reports on Projects

(i) DR 1 - Fluorides in Dental Caries

A report on this subject presented by Dr. J.J. Rae appears in full in APPENDIX "A".

Discussion

DR. THOMSON asked whether it would be possible to compare the rates of solution of human teeth of varying fluorine content as one means of studying the effect of fluorine on teeth.

It was AGREED to recommend research to determine the resistance of teeth of varying fluorine content in one (1%) percent lactic acid. Dr. Rae said that he would be glad to follow this suggestion.

(ii) DR 2 - Nitrous Oxide for Anaesthesia

A report on this subject presented by Dr. G. H. W. Lucas appears in full in APPENDIX "B".

Discussion

DR. GORDON said that in his experience the dew-point method always gave low results. He said also that in order to avoid errors from diffusion it would be necessary to use all glass apparatus and no rubber connections.

DR. BURTON inquired whether it was known at what water content of nitrous oxide freezing occurs.

DR. LUCAS said that no accurate information was available on this subject and that it would be quite an extensive problem to determine the relationship between water content of gas and freezing.

DR. FERGUSON thought the work should be finished up and published as it represented an important contribution to scientific knowledge on nitrous oxide.

It was AGREED in discussion that the British Pharmacopoeia specifications for nitrous oxide required revision particularly in reference to the permissible water content of gas. It was pointed out that the United States Pharmacopoeia makes no mention of the water content of nitrous oxide.

✓ (iii) DR 3 - Effects of Penicillin in Deep Pockets

In the absence of Dr. Box it was AGREED to defer consideration of the results of this research until a later meeting when Dr. Box would be present.

DR. E. F. BURTON showed some electron microscope photographs that he had made in connection with work in this field.

(iv) DR 4 - Packing in Periodontal Infections

MAJOR LINGHORNE said that he had nothing further to report on this subject at this Meeting.

(v) DR 5 - Acrylic Resin Denture Base

COL. COONS stated that he understood a report on this work had been prepared by Major R. L. Twible who was conducting the research but at the moment the report had not come to hand. He promised to secure the report and to send it in to the Secretary for inclusion in these proceedings. It appears in full in APPENDIX "C".

COL. COONS referred to the monograph prepared by the Ontario Research Foundation which appeared in the proceedings in the Second Meeting of the Associate Committee on Dental Research and said he understood that two additional reports had been prepared and that the work was continuing at the Ontario Research Foundation. He promised to secure copies of these two additional reports for inclusion in the proceedings.

These appear respectively as APPENDIX "D" and APPENDIX "E".

(vi) DR 6 - Effects of Altitude on Oral Tissues

COL. COONS presented a short report on this subject which appears in full in APPENDIX "F".

(vii) DR 7 - Dental Caries

THE CHAIRMAN said that Dr. Bagnall who has had this work in hand had written a letter to him which constituted an interim report on the subject. He read the relevant parts of the letter and these excerpts appear in APPENDIX "G".

It was moved by Dr. Ferguson and seconded by
Dr. Charron:

That the CHAIRMAN be asked to acknowledge receipt of Dr. Bagnall's Progress Report and express the Committee's commendation of his thorough and critical approach. The suggestion is made that when possible the opinion of local scientists be obtained on papers of questionable value. When this is not practical it is felt that the survey should try to mention all apparently relevant work.

CARRIED.

Copy for file

6. General Discussion

DR. BURTON inquired whether the Dental Colleges in Canada are making it possible for men on their staffs to do research work under the auspices of the Committee or whether they find that their teaching programmes do not permit them to give time to research.

THE CHAIRMAN said that he too was a little disappointed at the slowness with which the Associate Committee on Dental Research had been able to proceed thus far, but he thought it should be remembered that post-war conditions were placing a heavy load on teaching. Furthermore it was difficult to get men with the necessary background and time to carry on research. He pointed out that many promising young graduates have gone into the Dental Corps and that as a matter of fact the Senior class this year will also go into the Dental Corps as the last two years of their training had been paid for by the Army on the understanding that the graduates would go into the Corps as replacements for older men as required.

DR. BURTON said that in the Department of Physics at the University of Toronto sessional appointees were required to give two-thirds of their time to research and only about one-third to teaching. They had some fifty-five such appointees on their staff at the present time. He thought it was only possible to develop research men by freeing them from teaching responsibility and allowing them to carry on research work.

THE CHAIRMAN in reply said that as men were released from the Dental Corps it would become possible to take them on for research. At the present time those who had been released from the Dental Corps had engaged in part-time practice and part-time teaching. The difficulty about this arrangement was that their part-time practice gradually grew until they had no time left for anything

except their practice and teaching. He pointed out that the letter to the Deans of the Dental Schools had been despatched in the hope that it would stimulate interest in dental research and promote facilities for the conduct of such research.

DR. THOMSON asked whether any consideration had been given to the establishment of fellowships for dental research.

DR. COLLIF said that under the Associate Committee on Medical Research which had now been organized as a Division of Medical Research of the National Research Council, authority had been received for the granting of fellowships in the medical field. He showed a notice which had been despatched to all Medical Schools inviting applications for appointments in three grades of scholarships under the Division of Medical Research.

DR. CHARRON thought the Committee was making satisfactory progress. He pointed out that men trained for research in the dental field are yet few in number in Canada. He said that in the University of Montreal a careful selection was being made of undergraduates in the hope that they might prove adaptable for dental research a few years hence. He said that he had brought the proceedings of the Associate Committee on Dental Research to the attention of the heads of the basic science departments in the University and had asked them to give consideration to the subject particularly with a view to selecting men in their various fields who might subsequently be interested in carrying out dental research.

DR. THOMSON said he thought it was very important to bring the work of the Associate Committee on Dental Research to the attention of the other science departments in the universities e.g. chemistry, bacteriology and medicine. He pointed out that a metallurgist for example might be interested in carrying out a research that would be of great value to the dental profession. He doubted that competent metallurgists would have any knowledge of the existence of the Associate Committee on Dental Research unless some special effort were made to bring this fact to the attention of men in the other sciences. If the work and interests of the Committee could be more widely known he thought it would be advantageous to all concerned.

It was moved by Dr. Burton and seconded by
Dr. Stibbs:

That a descriptive pamphlet containing general information regarding the interests and activities of the Associate Committee on Dental Research be prepared by the Executive Committee and given wide distribution through the various departments of Canadian universities.
CARRIED.

7. Projects for 1946-47

(i) DR - 1 Dr. James J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

On motion of Dr. Burton seconded by Dr. Ferguson
this application was APPROVED \$900.00

(ii) DR 2 - Dr. Geo. H. W. Lucas

"Chemical study of nitrous oxide for dental anaesthesia"

DR. LUCAS submitted a revised application which included an item of \$950. as a re-vote from 1945-46 to cover the cost of the Cambridge Gas Analyser which he thought would probably not be delivered during the present year. He also revised the amount for remuneration for his assistant Dr. R.J.S. Tickle to cover ten months' employment and included an item of \$500. for travel in connection with the research.

On motion of Major Linghorne and seconded
by Dr. MacLean this grant was APPROVED \$2950.00

(iii) DR 3- Dr. Harold K. Box

"A study of micro organisms found in deep periodontal pockets and caries lesion as revealed by the electron microscope."
APPROVED

\$500.00

(iv) DR 4 - Dr. Harold K. Box

"An investigation of packing material in the treatment of periodontal disease"

This is a continuation of the investigation previously carried on by Major Linghorne. A description of the project submitted by Major Linghorne appears in APPENDIX "H".

On motion of Dr. Gordon seconded by Dr. Ferguson
this grant was APPROVED \$2200.00

MAJOR LINGHORNE in discussing this item of DR 4 outlined the need for a bacteriologist to aid in this study. He said that he had discussed the subject with Dr. C. H. Best and that Dr. Best would be willing to make the services of a bacteriologist available to Major Linghorne part-time for work in this field and to engage the bacteriologist for the rest of the time in his own laboratories. Major Linghorne then asked whether the Committee would support a further application for one thousand dollars (\$1000.) to pay for a bacteriologist to work half-time on this investigation.

DR. CHARRON said that it appeared to be very important that a bacteriologist should be employed but he thought that the original application only should be approved at this time and that a further application should be filed with the Committee in the regular way, provided that a competent bacteriologist could be found and satisfactory arrangements made for his employment on this work.

It was moved by Dr. Burton and seconded by
Dr. Thomson:

That the Executive be empowered to deal with any further formal application received regarding the employment of a bacteriologist to work on the investigation of packing materials in the treatment of periodontal disease for which a grant has been made under DR 4, the amount so expended for this purpose not to exceed \$1000. CARRIED.

ENCUMBERED

\$1000.00

(v) DR 5 - Major R. L. Twible

"To improve certain properties of the acrylic resin denture base and to effect an economy in denture production".

THE CHAIRMAN referred to the discussion on this grant (2nd Mtg.: Min. 5(v)) and reviewed the correspondence which had been exchanged with Dr. Speakman of the Ontario Research Foundation regarding the extent to which the Committee should support financially the investigation being carried on under the direction of the Ontario Research Foundation by Major Twible. He pointed out that approval had been given by the Committee to the payment of a sum of \$400. per month to cover direct expenditures involved in the employment of staff and the purchase of apparatus and that the Ontario Research Foundation had agreed to be responsible for

the overhead and depreciation items in the estimate of costs.

In a letter from Dr. Speakman dated 14 December 1945 two questions had been asked: "(a) Whether the work we (Ontario Research Foundation) are performing is worthwhile in the national interest and a project which they (the Committee) should sponsor and support; (b) What amount in relation to the total funds available can be allocated to this project?"

After full consideration and a lengthy discussion, it was moved by Dr. Burton and seconded by Dr. Gordon:

That Dr. Speakman be informed in reply to his letter that the Committee considers the problem on which Major Twible is engaged is of national importance, and that Dr. Speakman be thanked for the cordial cooperation he has shown in this project, and further informed that the Committee is willing to carry on this work in 1946-47 on the same basis as in 1945-46 on condition that an application is received from Major Twible.

CARRIED.

APPROVED \$400. per month/12 months = \$4800.

(vi) DR 6 - Col. D. S. Coons

"To study the effects of altitude acceleration and deceleration on oral tissues."

COL. COONS explained that this work could be carried on under the Dental Corps and that no grant was yet required from the Associate Committee. The project was APPROVED for continuance in 1946-47 as a Committee project but without a grant.

(vii) DR 7 - Dr. J. S. Bagnall

"Critical survey of the literature on dental caries".

DR. BAGNALL had applied for \$200. plus the unexpended portion of his 1945-46 grant. As funds granted in any one year may not be carried over into the next fiscal year the Committee decided to grant \$300. to Dr. Bagnall. APPROVED \$300.

(viii) DR 8 - Drs. O.J. Walker and
H. R. MacLean

"An investigation of the effects of
certain chemicals on materials in
appliances used in prosthetic dentistry."

It was moved by Dr. Charron and seconded by
Dr. Ferguson:

That this grant be APPROVED \$1000.

8. Fluorine as related to teeth

THE CHAIRMAN recalled that the subject of fluorine as related to teeth had been raised in previous meetings of the Committee and he thought that it would be useful to have a discussion on this subject. By way of introduction he asked the Secretary to read a letter which had been received by the President of the National Research Council from Dr. A. Gregor Smith, Secretary, Brantford County Dental Society in which reference was made to a short account of the Brantford fluorine experiments which had been published in the Journal of the Canadian Dental Association. The letter continued as follows:

" As this experiment now being carried on here will be of great interest to municipalities throughout Canada it is felt that the Research Council should cooperate and give aid in making a thorough survey and in every way assist in proving the worth or otherwise of the use of fluorine in communal water supplies.

" In a recent letter to me Dr. M. H. Garvin, Editor of the Journal, said, "If there are no disadvantages to placing fluoride in the water supply then from a dental caries standpoint it should be placed at once in the water supply of every community in Canada."

" Stratford, a city similar in size to Brantford and lying fifty miles west, has for twenty-seven years been getting its city water supply from five deep wells that contain an average content of fluorine of 1.16 P.P.M. Here then would seem to be an ideal situation for proving the beneficial or detrimental effects of fluorine as aside from this chemical constituent the people of the same type are apparently living in an area where the soil and other conditions are the same as this city.

" If a thorough examination and survey could be made of the teeth and mucosa of all the children in the grade

schools in the two cities it would to a great extent clear up the whole situation as far as the dental profession and boards of health throughout Canada were concerned. The members of the Brant County Dental Society are willing to give time in taking X-ray radiograms and assist in any way when requested but we feel that it is a real worthwhile undertaking for the dental research branch of the National Research Council."

THE CHAIRMAN distributed copies of maps (i) showing the distribution of fluorine in water supplies in Ontario; (ii) showing the location of fluorospar deposits in Canada. See APPENDIX "I" and APPENDIX "I-2" .

THE CHAIRMAN then invited Dr. W. H. Hutton, Medical Officer of Health, City of Brantford, to outline the Brantford experiment to the members.

DR. HUTTON reviewed the development of work relating to fluorine in drinking water supplies. He said that interest in this subject had developed as long ago as 1925 in Idaho where in a study of mottling of the teeth it was found that the water supply contained six (6) parts per million of fluorine. The source of water supply had been changed and there had been a marked improvement in the teeth of the people in succeeding years. There were also reports from Naples in 1927 that dental caries was not found when fluorine occurred in water supply. In 1939 peculiar conditions had been found in Deaf Smith County where mottled teeth occurred in 61 per cent of the persons examined. In his own city of Brantford it had been found on examination of 2714 cases only 141 had perfect teeth and the D.M.F. rate per child was 7.66. Dean of the United States Public Health Survey had made comparative studies in Galesburg Illinois, and Quincy Illinois and had found that in the latter city where the water supply contained 0.2 P.P.M. fluorine the D.M.F. rate was 8.9 per 100 whereas in Galesburg where the fluorine content was slightly higher the D.M.F. rate was only two (2).

In January 1945 Grand Rapids, Michigan, added fluorine to its water supply and had become the first city in the world to adopt this practice. Brantford followed only shortly later. Dr. Hutton said that he thought the best work on fluorine and water supplies was being done under the Direction of Dr. Ast in Newburgh, New York. Ast had published a booklet entitled "Fluorine in Dental Public Health" which was a complete resumé of the subject. Funds for the investigation had been provided by the United States Public Health and about \$30,000. per year was being spent in the Newburgh experiment. He said that Brantford had approached the Government of the Province of Ontario for assistance in this work but had not yet been able to obtain any

support. Nevertheless the City was going forward with the scheme and the opportunity was now being offered for the examination of the teeth of the children who heretofore have been supplied with water which was free from fluorine but which now contains about one part per million. Records kept over succeeding years would show whether the experiment was useful.

DR. MACLEAN said that some work had been done in Alberta on fluorine by Dr. Gilchrist of the University of Alberta. The records were on file but had not yet been tabulated for publication. In some areas in Alberta it had been found that the fluorine content of the drinking water supplies was so high that consideration had to be given to the removal of fluorine rather than to the addition of fluorine. He presented a tabulation showing the distribution of fluorine waters in Alberta which appears in APPENDIX "J".

THE CHAIRMAN said that in Brantford 55 cases of mottled teeth had been found among children who had not been exposed to drinking water containing fluorine. He emphasized the importance of undertaking surveys of the effects of fluorine on teeth at the present time pointing out that there were areas in which fluorine had been a constituent of the drinking water for many years past, that there were other areas in which fluorine is now being added in measured amounts to the drinking water supply and that there are still areas where no fluorine is present in the drinking water supply. Adequate surveys in these three areas should provide valuable information for the guidance of those who have authority over community water supplies.

As regards the question of whether surveys could be considered research he said he thought the establishment of facts constituted research and that what was done with the results might be a function of public health authorities. In the present instance it was proposed to determine the facts and in this sense the work appears to be definitely within the realm of research.

DR. FERGUSON said that he thought it might be advantageous to discuss this problem with the Department of National Health and Welfare before engaging in research on the subject of fluorine as related to teeth. It would be desirable to obtain the views of the Department and to inquire as to their interest in particular phases of the programme.

It was moved by Dr. Ferguson and seconded by
Dr. MacLean:

That the Chairman discuss the proposed programme of work on fluorine as related to teeth with appropriate officials of the Department of National Health and Welfare and that the Executive be empowered to authorize grants-in-aid of research on this subject for 1946-47 in the amount of \$6000. APPROVED \$6000.

It was moved by Dr. Ferguson and seconded by

Major Linghorne:

That the Chairman of the Committee be authorized to spend up to \$1000. in 1945-46 to organize and conduct a survey on the relation of fluorine to dental caries. This project was designated DR 9 and APPROVED \$1000.

9. Dental Caries and Water Supplies

THE CHAIRMAN drew attention to the fact that reprints of a paper entitled "Dental Caries and Water Supplies" by Dr. Harold K. Box and Dr. H. J. Hodgins had been distributed to members of the Committee for their information.

10. Letter to Dr. Bagnall

It was AGREED that a letter should be despatched to Dr. Bagnall asking him to concentrate on the subject of fluorine as a section of the Bibliography which he has now in preparation as it was thought that the references on this subject should be collected immediately for the guidance of those who are interested in research in the use of fluorine in water supply.

11. Reprints of Papers

THE SECRETARY suggested that it might be useful to ask members of the Committee to supply 25 copies of reprints of any papers which they may publish on subjects of research sponsored by the Committee in order that such reprints may be made available to members of the Committee.

It was moved by Dr. MacLean and seconded by

Dr. Charron:

That 25 reprints of all papers on dental research, published by members of the Committee, be supplied to the Secretary of the Committee for distribution to the members, and that the expenses incurred for such reprints be defrayed out of Committee funds.

CARRIED.

12. Office Expenses

THE SECRETARY said it would be convenient to have a small fund to meet incidental expenses in connection with the work of the Dental Committee and it was AGREED that for 1945-46 the sum of \$100. should be provided. APPROVED \$100.

It was also AGREED that in 1946-47 an item of \$500. should be provided for "dental contingencies". For 1946-47, APPROVED \$500.

13. Travel Expenses

In order to provide for the attendance of members at meetings of the Committee it was AGREED that the budget for 1946-47 should include \$2000. for travelling. APPROVED \$2000.

14. Budget for 1946-47

Budget requirements for 1946-47 in the light of the grants recommended in these proceedings and with a small provision of about \$3000. for unforeseen projects amounted to about \$25,000.

It was moved by Col. Coons and seconded by
Dr. Stibbs:

That the Associate Committee on Dental Research recommend to the National Research Council that \$25,000. be provided in 1946-47 for this Committee.

CARRIED.

15. Membership of the Committee

THE CHAIRMAN pointed out that as noted in APPENDIX "A" of the proceedings of the First Meeting of the Committee the terms of four members expire 31 March 1946. These members are:-

Dr. H. K. Box, Research Professor of Periodontology
University of Toronto, Toronto, Ont.

Dr. G. D. Stibbs, Member of the Board of the British
Columbia Dental Association,
Vancouver, B.C.

Dr. E. F. Burton, Professor of Physics and Head
of the Department and Director
of McLennan Laboratory, University
of Toronto, TORONTO, Ontario.

Dr. J. B. Collip, Research Professor of
Endocrinology and Director
of the Research Institute
of Endocrinology, McGill
University, Montreal, Que.

Appointments to Committee membership are normally for three years and one-third of the number of members retire each year. A retiring member may be appointed for a second term following which he shall retire from the Committee for at least a year. The term of membership of representatives of the Canadian Dental Corps is continuous during the time each represents the Dental Corps on the Committee.

It was moved by Dr. Thomson and seconded by
Major Linghorne:

That the Associate Committee on Dental Research
recommend to the National Research Council
that the four members whose terms expire
31 March 1946 be reappointed for a second
term of three years.

CARRIED.

16. Summary of New Projects

Reference was made to 2nd Mtg: Min. 8, regarding the summarizing of applications. After the subject had been discussed it was AGREED that all applications should be in the hands of the Secretary at least one month before the Meeting at which they are to be considered. It was thought that this interval was necessary in order that the application might be summarized and the summaries distributed to the members prior to the meeting.

17. Reports on Researches

It was AGREED that reports on all continuing researches should be requested for presentation at the autumn meeting of the Committee. These would be interim reports and final reports would be required before the end of the fiscal year.

The Meeting adjourned at 4:00 p.m.

APPENDIX "A"

THE CHEMICAL MECHANISM OF FLUORINE ACTION ON DENTAL CARIES

Interim Report on DR-1

Period Covered - October 1, 1945 to February 15, 1946.

Research Workers - James J. Rae, Ph.D., Charles T. Clegg, Phm.B.,
Chemistry Department, University of Toronto.

In an attempt to gain further insight into the chemical mechanism by which fluorine prevents dental caries, whole teeth were suspended in buffered 1% lactic acid solutions at pH 3.8 with and without the addition of small amounts of sodium fluoride. There was no visible decalcification in 24 hours when fluoride was present, but decalcification under the same conditions was marked in the presence of fluoride, as already shown by Dr. H. Box.(1)

By the use of this technique a number of substances were investigated to see if they also exhibited this protective effect. In many cases the added material raised the pH above 4.0, and no decalcification occurred; in others suspensions and emulsions were formed which made it difficult to measure the effective amount of added material present.

These experiments led to a definition of a "protective agent" - viz. a soluble material which will prevent visible decalcification of whole teeth immersed in 1% lactic acid at pH 3.8 for a period of 24 hours.

(a) Experiments with Tricalcium Phosphate

In order to remove complicating factors that might arise from differences in individual teeth, pure tricalcium phosphate was shaken with 1% lactic acid solutions with and without the addition of sodium fluoride. The decrease in the weight of calcium phosphate left in the tube containing fluoride was only one-third the decrease observed when no fluoride was present.

Sodium fluoride reduces the "apparent solubility" of calcium phosphate in lactic acid. That this decrease in solubility is only apparent is shown by the fact that the phosphate concentrations in the supernatants are the same with and without the addition of fluoride.

Phosphate values determined at various time intervals did not change appreciably after the first thirty minutes, showing that solubility and not just rate of solution was being measured. The phosphate values were also found to be independent of the concentrations of fluoride used (0.005 to 0.05 molar). These results, taken in conjunction with the fact that the calcium concentration is much lower in the tubes containing fluoride, would suggest that calcium fluoride is being precipitated and that the apparent decrease in solubility is simply the difference in weight between the calcium phosphate dissolved and the calcium fluoride precipitated.

(b) Experiments with Powdered Tooth Enamel

When powdered tooth enamel (60 mesh) prepared according to the method of Manley and Hodge(2) was used instead of tricalcium phosphate, analogous results were obtained except that a slightly longer time (4 hours) was required before saturation was reached.

On the basis of the mechanism proposed for calcium phosphate, any cation which produces an insoluble salt with phosphate (such as lead or barium) or any anion which produces an insoluble salt with calcium (such as oxalate) should also decrease the "apparent solubility" of powdered tooth enamel or calcium phosphate in lactic acid. Ammonium oxalate, barium nitrate and silver nitrate were found to have such an effect. Silver fluoride which produces ions that will precipitate both phosphate and calcium exhibits a marked effect on the apparent solubility of tooth enamel. The addition of lead nitrate causes an increase in weight of residue in the tubes due no doubt to the fact that the molecular weight of lead phosphate is greater than calcium phosphate. Double strength Robison (3) calcifying solutions (16 mg. Ca and 10 mg. P per 100 ml.) were found to have a slight depressive effect on the "actual" solubility of tooth enamel. That this is "actual" and not "apparent" solubility is shown by the fact that the increment in phosphate values obtained in the tubes containing Robison's solution was lower than in the control tubes.

(c) Experiments with Whole Teeth

When whole teeth were used the following materials, in addition to sodium fluoride, were found to be "protective agents":- sodium oxalate, barium, lead and silver nitrates and silver fluoride.

One essential difference between the whole teeth experiments and the calcium phosphate and tooth enamel experiments is that the phosphate values continue to rise slowly even after a period of a week, showing that equilibrium has not yet been reached. This is due no doubt to the organized structure of tooth enamel and the smaller surface exposed. Sodium benzoate, tartrate, arsenate, sulphate,

sulphite, bisulphite, glycerophosphate, citrate and silicate were found to have little if any protective effect in the concentrations investigated.

Table I represents a composite picture of results obtained by adding the chemicals shown in the first column to whole teeth suspended in 1% lactic acid; to tooth enamel and to tricalcium phosphate suspensions shaken with 1% lactic acid. In the experiments involving whole teeth, no decalcification was observed in any case.

TABLE I

Material added	WHOLE TEETH		TOOTH ENAMEL		CALCIUM PHOSPHATE		
	Mg.P per 10 ml.	Mg.Ca per 10 ml.	Change in Wt.Mg.	Mg.P per 10 ml.	Change in Wt.Mg.	Mg.P per 10 ml.	Mg.Ca per 10 ml.
Sodium Fluoride 0.01 M	2.83 (9.51)	7.96 (23.2)	-25 (-50)	3.34 (5.63)	-50 (-80)	5.9 (6.0)	9.0 (30.6)
Ammonium Oxalate 0.01 M	1.22 (5.6)	- *	-36 (-65)	7.0 (5.0)	-22 (-68)	9.8 (11.6)	-
Lead Nitrate 0.05 M	0.78 (5.27)	3.83 (25.9)	+10 (-38.2)	0.27 (5.7)	+66 (-67)	0 (8.72)	
Silver Fluoride 0.01	2.41 (9.51)	7.40 (23.2)	+8 (-50)	7.5 (5.6)	+24 (-67)	4.32 (8.72)	

* Sodium oxalate used with whole teeth.
Numbers in brackets refer to control tubes.

NOTE: In view of the fact that a rapid micro-method for the determination of fluorine would give an insight into changes in the fluoride concentration of the solution and the teeth during immersion in lactic acid, a recently proposed titrimetric method suggested by Bien (4) was investigated.

CONCLUSIONS

The protective effect of fluoride in these in vitro experiments on teeth seems to be due in part to the deposition of calcium fluoride which replaces the tooth enamel dissolved by

lactic acid. The evidence for this statement is:-

1. When teeth are suspended in 1% lactic acid containing added fluoride, no visible decalcification occurs, but the phosphate in the supernatants increases with time showing that the enamel is being dissolved.
2. The addition of fluoride to suspensions of powdered tooth enamel and tricalcium phosphate in 1% lactic acid has no effect on the amount of phosphate dissolved, but reduces the apparent solubility of both these materials due to the re-deposition of the calcium as calcium fluoride.
3. Oxalate ions which also form insoluble calcium salts exhibit entirely analogous effects, i.e. protect teeth and decrease apparent solubility of tooth enamel and tricalcium phosphate.
4. By an analogous mechanism cations which form insoluble phosphates also have a protective effect and decrease the apparent solubility of tooth enamel and tricalcium phosphate.

PROPOSED WORK:- To investigate the relationship between salivary phosphatase and fluorine.

References.

- 1.Box, H.K. and Hodge, H.J. Water and Sewage 82, 42, 1944
- 2.Manley and Hodge H.C. Journ.Dent.Res. 118, 133, 1939.
- 3.Robison, R. and Rosenheim, A.H. Biochem.Journ. XXVIII, 684, 1934.
- 4.Bien, S.M., Journ. Dent. Res. 22, 123, 1943.

APPENDIX "B"

CRITIQUE OF METHODS USED IN DETERMINING THE WATER
VAPOUR CONTENT OF NITROUS OXIDE

Interim Report on DR-2

by

Dr.G.H.W. Lucas
and Dr.R.J.S. Tickle

Estimations of the water vapour content in anaesthetic nitrous oxide by the B.P. 1932 method using a P₂O₅ tower, varied considerably in samples drawn from the same tank. There was some evidence that water vapour diffused through the rubber tubing to the P₂O₅ tower.

Measurements made using a method in which the water vapour was removed by freezing it out in a tared trap immersed in a cooling solution at -79°C., were more consistent but still unsatisfactory. Better results were obtained by titrating the water collecting in the trap with Fischer's reagent. The amount of rubber tubing employed must be a minimum. It should be used only for connections of glass tubing and these connections should be waxed.

APPENDIX "C"

REPORT ON DR 5 - DENTURE BASE MATERIALS

by Dr. R.L. Twible

Throughout the past year several visits were made by the undersigned to various manufacturers and fabricators of acrylic materials for the purpose of observing the method of manufacturing and processing.

These visits were made as members of the C.D.C. and under military auspices. Calls were made on the following firms:

The Dentists' Supply Company - New York
Luxene Company - New York
H.D. Justi and Sons Inc. - Philadelphia
Dental Laboratories in New York, Philadelphia
and Detroit.

The Ontario Research Foundation are proceeding with this work as outlined. A previous monograph, No. 4501, was previously submitted. There is attached herewith monographs 4502 and 4601 covering the work done to date. (Appendices "D" and "E")

At one of the monthly meetings held at the Ontario Research Foundation, Dr. Speakman suggested that any information regarding dental materials and methods of processing be withheld until such time Mr. D.R. Christie had completed his preliminary research. Mr. Christie has however submitted the above mentioned monographs.

1 March 1946.

APPENDIX "D"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Denture Research Report No. 4502

by D. R. Christie

Scope of This Report

Since October 25, 1945, the research on this fellowship has been confined to a study of the polymerization process in order to acquire some fundamental information on which to base further work. This report deals with preliminary qualitative experiments and later more quantitative experiments on the polymerization conditions of methyl methacrylate resins.

Outline of Preliminary Experiments

After the technique of making dentures had been learned at the C.D.C. Training Centre, several were made here under varying conditions. Some steps of the approved C.D.C. technique were deliberately altered to learn how the changes affected the quality and appearance of the dentures. For example, dentures were made using quantities of monomer and polymer recommended by the manufacturers of the plastic and therefore different from those specified at the Training Centre; others were cured under extremes of polymerization conditions, such as immersion of the denture flask in boiling water and also in cold water which was gradually raised to boiling. These experiments produced dentures with varying degrees of porosity but the results served chiefly to give some experience in technique and information of the general behavior of the denture material.

Useful quantitative data were obtained by processing several methacrylate cylinders or discs measuring approximately 1 1/2 inches in diameter and 1/2 inch in height. During polymerization under different curing conditions, the temperatures of the discs were measured by a thermocouple inserted through the plaster mold. When the results are shown on a graph, interesting facts can be easily seen. The accompanying graph shows the temperatures of the water bath in numbered, broken lines and the corresponding Lucitone temperatures in numbered, characteristically-marked, solid lines.

Experiment 1

The flask containing a disc of Lucitone was immersed in boiling water.

The temperature of the disc rose rapidly in 20 minutes to the polymerization or "kick-over" point which apparently is about 180° F. and then climbed almost immediately to a peak of 247° F. After attaining this maximum it at once began to fall again and actually dropped below the temperature of the water bath. This shows that there is a lag in the temperature of the plaster behind the water bath temperature and that the plaster absorbs the heat of reaction to some extent.

The increase of Lucitone temperature over the polymerization point was in this case 67° F.

The disc produced was free of porosity on the surfaces but the centre contained many minute pores which gave the effect of a white cloud.

Experiment 2

The flask was placed in cold water which was brought to a boil in about 80 minutes.

The temperature of the disc lagged behind during the entire heating but again when it reached 180° F. it rose rapidly to a maximum of 216° F. or an increase of 36° F. over the polymerization point. Again the disc cooled to below the bath temperature and would eventually have come to the same temperature on longer heating.

This disc was also free from porosity on the surfaces but contained large pores in the interior.

Experiment 3

The flask was placed in a bath of 160° F.

The disc temperature increased rapidly at first and then approached 160° F. more slowly as the differential became less. When it seemed that too long a time would be consumed for the plastic to heat to 160° F. and that polymerization might not occur, the bath was heated to a new level of 190° F. The disc temperature was brought to 180° F. where once again polymerization began, and this time a peak of 225° F. was reached - an increase over the polymerization point of 45° F.

This disc was porous from surface to surface but most of the porosity existed at the centre.

Experiment 4

The flask was put in boiling water and when the thermocouple indicated that the polymerization temperature was nearly attained, the bath water was changed and replaced by cold water.

On the first trial, polymerization did not occur and the temperature began to fall. On the second trial readings of the disc temperature began at 116° F. and rose rapidly to 175° F. where the bath was changed again. The disc remained at 175° F. for about 4 minutes and then rose to a peak of 213° F., an increase of 38° F. However, this maximum was the lowest of all four experiments and the following drop was the most rapid of all.

This disc contained evenly distributed porosity from surface to surface.

Except for Experiment 4, the results seem to indicate that the longer the curing time the lower is the maximum temperature and the smaller is the peak rise.

Experiment 4 shows that the peak can be reduced if the surrounding bath temperature can be lowered before the "kick-over" point is reached, but polymerization will be prevented by a premature cooling. If such a technique has any merits it would have to be worked out on a time basis.

The general appearance of this disc was more homogeneous and more free from porosity than the others, which suggests the desirability of studying the technique of temperature control more fully.

Experiments with a Hydraulic Press

A hydraulic press capable of exerting considerably more pressure than a spring clamp and equipped with rheostat-controlled heating platens was used to press several thin discs of Lucitone. The purpose was to see how Lucitone, molded under the most favorable conditions, compared in appearance with Lucitone, molded by the usual dental technique, especially with regard to homogeneity.

A diagram of the mold in the press will illustrate how the discs were cured, and accompanies this report.

A thermocouple was inserted inside the mold to within 1/4 inch of the Lucitone and a thermometer in the lower platen. Since the plastic was close to the bottom of the mold the temperature of the lower platen would be approximately the same as the plastic. By adjusting the rheostats, it was possible to maintain the temperatures on both sides of the disc about the same.

On the first two trials of 70 and 85 minutes respectively, the platens were heated from room temperature to a maximum of 237° F. under a total pressure of 1600 lb./sq. in. in one case and to 248° F. under a total pressure of 3200 lb./sq.in. in the other.

A sudden rise in the thermocouple reading, corresponding to the heat of polymerization of previous experiments, was not detected in either case, although polymerization actually occurred. However, it should be borne in mind that the thermocouple was not actually in the Lucitone.

Apparently the metal mold, in contact with the Lucitone, conducted away the heat of polymerization as fast as it was produced and did not allow the temperature to build up and be localized in the Lucitone. The discs produced were free of any porosity.

Since the actual moment when rapid polymerization began in the mold could not be determined by thermocouple readings, a few discs were pressed for much shorter times under a total pressure of 3200 lb./sq. in. and while the platens were at their maximum temperatures of about 320°F.

Polymerization occurred in intervals as short as 7 1/2 minutes, and perhaps in less time than this. In all cases no porosity occurred.

High pressures and temperatures in a metal mold make a good product. The results show that even under these conditions, when the molded mass is free from actual porosity, the remains of the interfaces of the polymer spheres are more or less in evidence due to the presence of the coloring material and the mass is far from homogeneous.

The results also reveal the kind of appearance we should look to as an objective or standard in the more moderate treatment of the usual dental technique.

These experiments indicate that a peak rise of temperature on polymerization can be minimized or avoided if the mold can conduct away the heat as it is generated. An approach to this condition in a plaster mold in a denture flask, conceivably would make for a better product.

The use of thermoplastics or the incorporation of metal powders in the plaster to attain greater conductivity should definitely be investigated.

Program of Research

In Report No. 4501, the following topics were considered worthy of investigation:

- I. (a) Comparison of Lucitone and Kallodentine
- (b) Polymer Particle Packing
- (c) Study of Present Catalyst and Polymerization Process
- (d) Shrinkage Compensation or Prevention
- (e) Finishing Study A and B
- (f) (g) Porosity and other Tests.
- II. Other Available Plastics
- III. Other Processes

Further Investigation

(a) Polymerization Process

All of these sections are being kept in mind, but so far work has dealt chiefly with Section I (c). In connection with the present process, the study of Sections I (a) and I (b) will be continued in an effort to learn more of the polymerization process.

(b) Effect of Peak Temperature on Polymerization

The results of the preliminary experiments suggest a possible relation between peak temperature and commonly occurring defects such as strain, shrinkage and porosity.

In this connection it is proposed to investigate any differences in degree of polymerization caused by the differences in peak temperatures.

If any differences do occur it may be possible to eliminate them and thus eliminate strains by an annealing process.

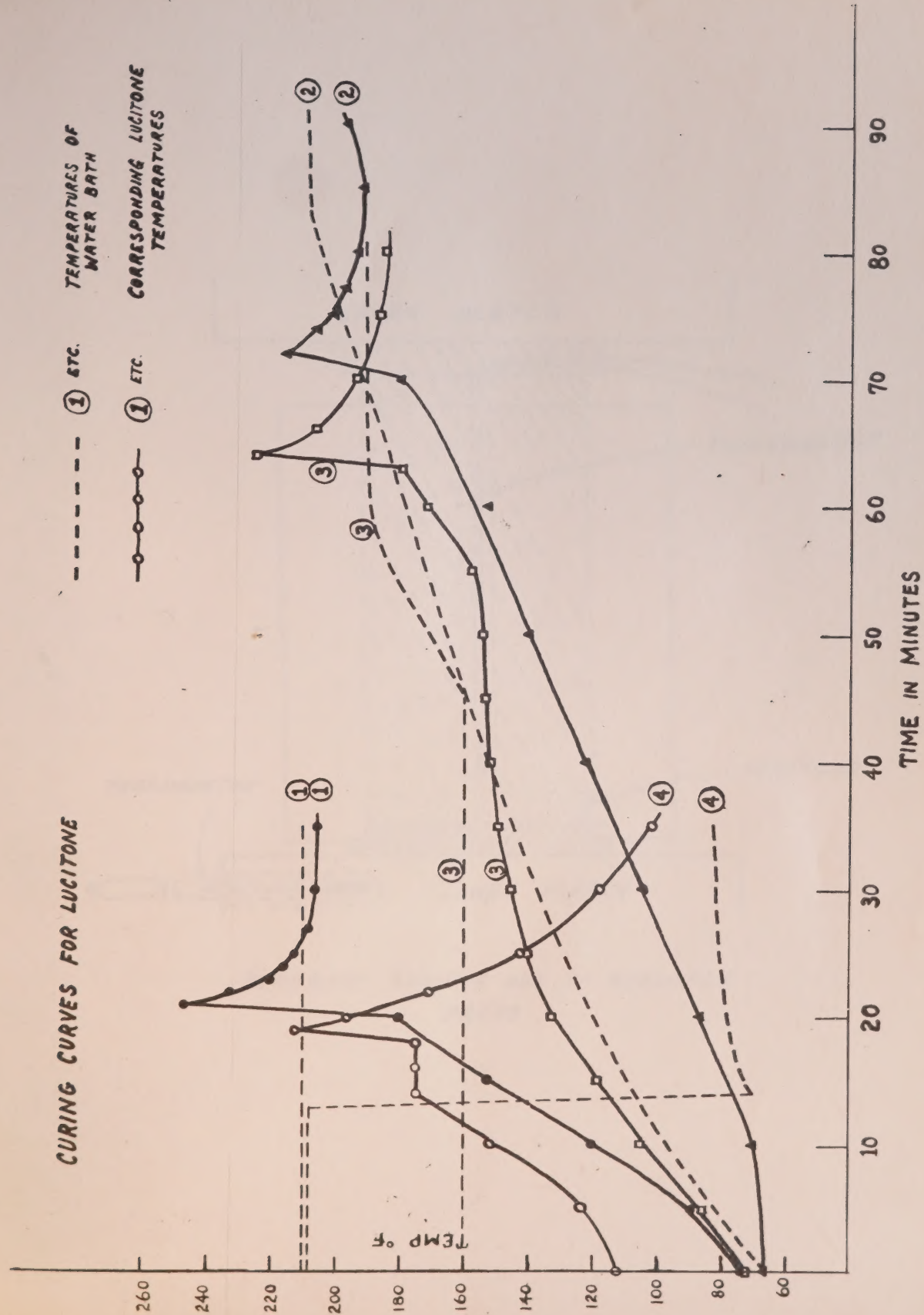
CURING CURVES FOR LUCITONE

TEMPERATURES OF
WATER BATH

TEMPERATURES OF
CORRESPONDING LUCITONE

① ETC.

① ETC.



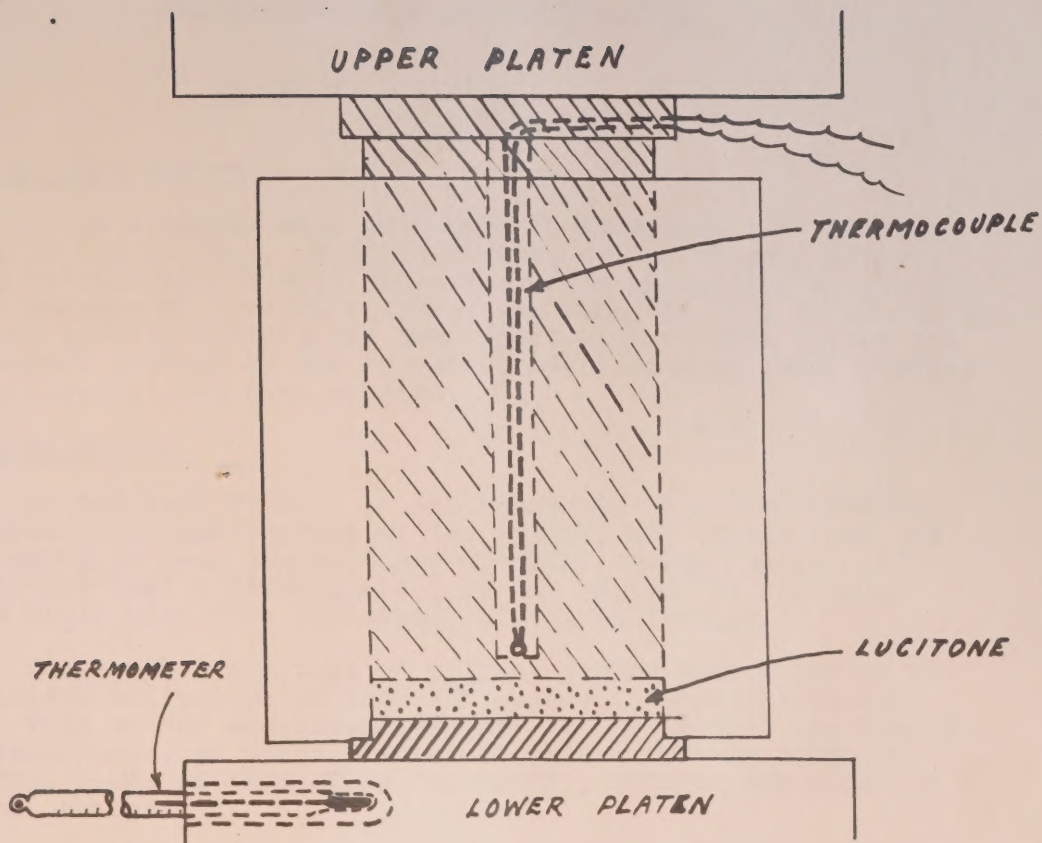


DIAGRAM SHOWING USE OF HYDRAULIC PRESS.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Denture Research Report No. 4601

by D. R. Christie

Scope of This Report

A few attempts have been made to determine the softening points of the polymer. Further studies on the thermal effects during polymerization have been made. The absorption of monomer by the polymer at lowered temperatures with the idea of producing a better molding mixture has been dealt with to some extent and preliminary studies of the effect of incorporating metal powders in the plaster have been started.

Softening Points

In the last report, it was suggested that a difference in degree of polymerization of the polymer may result from the differences in peak temperatures attained during curing. It was thought that a determination of the melting or softening points would give some indication of any difference.

Two small quantities of polymer powder were inserted in a capillary melting-point tube and heated in a sulphuric acid bath. This method was unsatisfactory as the polymer was heated to a temperature of 335°F., which is well above the accepted softening range of from 220°F. to 260°F., without any apparent physical change.

Strong heating of the polymer in the melting-point tube caused the formation of a condensate in the upper part of the tube and a sample heated on a metal spatula began to bubble before any flowing or softening was noticed and eventually evaporated. This would indicate that strong heating causes depolymerization.

Further efforts will be made to determine the softening points by another method as soon as the apparatus is available for this purpose.

Thermal Effect on Polymerization

In the previous report, some information of this process was presented from the results obtained by curing several discs of Lucitone under varying conditions.

Comparisons have now been made of the polymerization curves of Kallodentine and Lucitone polymers and Kallodentine and Lucitone monomers as well as a monomer obtained from the Peters Chemical Manufacturing Company in the United States.

Mixtures of these monomers and polymers in the proportions of 3 cc. of monomer to 10 cc. of polymer were allowed to reach a workable consistency at room temperature, then placed in a test tube and put in a constant temperature water-bath at $165^{\circ} \pm 2^{\circ}\text{F}$. Temperatures of the polymerizing plastic were recorded by the use of a thermocouple.

The results are shown on graphs accompanying this report.

Experiment 1 - Lucitone monomer and polymer

Time to reach peak: 10 minutes

Increase over bath temperature: 92°F .

Experiment 2 - Kallodentine monomer and polymer

Time to reach peak: 20.5 minutes

Increase over bath temperature: 61°F .

Experiment 3 - Lucitone monomer and Kallodentine polymer

Time to reach peak: 10 minutes

Increase over bath temperature: 110°F .

Experiment 4 - Kallodentine monomer and Lucitone polymer

Time to reach peak: 37 minutes

Increase over bath temperature: 42°F .

Methyl methacrylate monomer, obtained from the Peters Company, contained 0.006 per cent of hydroquinone as an inhibitor and was distilled to remove it.

Experiment 5 - Peters' distilled monomer and Lucitone polymer

Time to reach peak: 12 minutes

Increase over bath temperature: 72° F.

Experiment 6 - Peters' distilled monomer and Kallodentine polymer

Time to reach peak: 6.5 minutes

Increase over bath temperature: 82° F.

Since Kallodentine monomer reacts more slowly than do Lucitone monomer and Peters' monomer, a small amount of Kallodentine was distilled to remove any inhibitor which might be present. Two more polymerizations were carried out using this distilled monomer.

Experiment 7 - Distilled Kallodentine monomer and polymer

Time to reach peak: 6 minutes

Increase over bath temperature: 145° F.

Experiment 8 - Distilled Kallodentine monomer and Lucitone polymer

Time to reach peak: 10.5 minutes

Increase over bath temperature: 133° F.

Apparently distillation has removed an inhibitor which now results in a higher peak being reached in a shorter time.

The Peters' monomer containing 0.006 per cent of hydroquinone should show less reactivity than the same distilled monomer.

Experiment 9 - Peters' undistilled monomer and Kallodentine polymer

Time to reach peak: 16.5 minutes

Increase over bath temperature: 70°F.

Experiment 10 - Peters' undistilled monomer and Lucitone polymer

Time to reach peak: 32.5 minutes

Increase over bath temperature: 51°F.

The use of clear Lucitone polymer in which porosity may be more readily seen and which would be necessary for proposed future work on strains, suggested that something should be known of its polymerization curve. It should be expected to react similarly to the pink Lucitone polymer.

Experiment 11 - Peters' undistilled monomer and clear Lucitone monomer

Time to reach peak: 23.5 minutes

Increase over bath temperature: 62° F.

Experiment 12 - Peters' distilled monomer and clear Lucitone monomer

Time to reach peak: 10 minutes

Increase over bath temperature: 100°F.

Actually the pink Lucitone polymer does not react quite as quickly as the clear.

The results of these experiments show, in general that

(1) the order of reactivity of the polymers is Kallodentine > Lucitone clear > Lucitone pink.

(2) the reactivity of the monomers seems to depend on the polymer that is used. However, they may be grouped roughly in three classes.

(a) Distilled Kallodentine has a high reactivity

(b) Lucitone and Peters' (distilled) are less reactive

(c) Kallodentine and Peters' (undistilled) are least reactive.

(3) the removal of an inhibitor has a marked effect on the rate of polymerization.

Absorption of Monomer

If the monomer and polymer mixture is allowed to stand for a considerable time without passing the "doughy" or workable stage, the monomer should penetrate the polymer particles more thoroughly than it does in the ordinary procedure of mixing before packing which usually takes about half an hour at room temperature. That absorption does occur can be seen to some extent by a microscopic examination of polymer particles before and after several hours of contact with the liquid monomer. At lower temperatures, such as in a refrigerator, it is possible to allow a mix to stand for as long as 72 hours and still use it at the end of that time.

Experiment 1 - As a control, a mixture in the proportions of 3 cc. of monomer to 10 cc. of polymer was processed after becoming workable at room temperature. Peters' distilled monomer and clear Lucitone were used in this and following experiments.

The mixture was trial-packed and processed without teeth and tinfoil for one hour at 212° F.

This denture was milky white and full of porosity.

Another, processed in the same way, turned out much better. It still had considerable internal porosity and some surface porosity in the lower palate area.

Experiment II - A mixture of the same materials in the same proportions was put in a refrigerator at about 40°F. for 48 hours and then cured as above. This denture was quite clear and contained little surface porosity but the interior was still decidedly porous.

Experiment III - A mixture of the same materials using 3 cc. of monomer to 5 cc. of polymer (an excess of monomer) was allowed to become workable at room temperature over a period of 5 days. At the end of this time, the mixture had become as clear as glass as the monomer had evidently penetrated to the centres of the polymer particles. This was processed as before and the resulting denture was very clear, contained no porosity but did show several large holes especially in the palate area.

There are obvious difficulties in making a smooth mold with 30 mesh aluminum but they may be overcome by the use of a finer powder which will be obtained.

The thermal curve was not obtained, as difficulty was again encountered with a probable short-circuiting of the thermocouple. This would be interesting and should be attempted again in the future.

Summary of Comparison of Lucitone and Kallodentine

The comparison of the commercially available types of monomers and polymers indicate that Lucitone monomer or Peters' monomer and Lucitone polymer can be expected to produce as satisfactory results as are possible by the present process. The Kallodentine which we have studied should not allow of immediate immersion in boiling water and still produce a good denture. There would seem to be no advantage in continuing a comparison of the polymerization process with the materials on hand.

Programme of Research

I. (a) Polymerization Process

(b) Shrinkage Compensation or Prevention

(c) Finishing Study A and B

(d) Porosity and Other Tests

II. Other Available Plastics

III. Other Processes.

Further Investigation

1. Absorption of Monomer

The absorption of monomer and its use in the correct proportions are suggested by Experiment III under the section Absorption of Monomer.

2. The Effect of Peak Temperature on Polymerization

This problem was mentioned at the beginning of this report and may be elucidated in future work by other methods.

3. Polymerization Process

Further work with the use of different metal powders and the thermal properties during polymerization will be investigated.

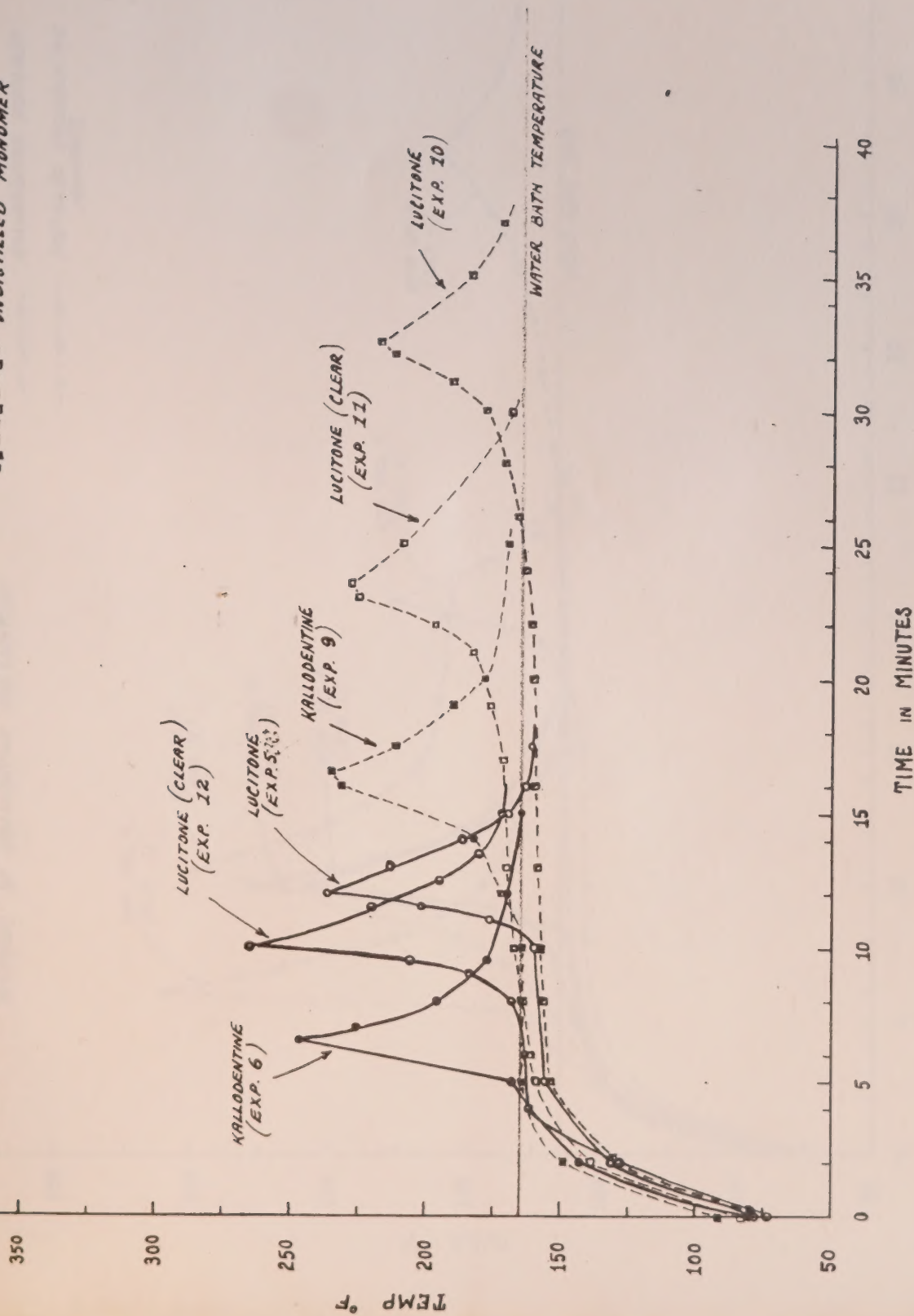
4. Strains

Enquiries have been made about apparatus which could be used to determine strains in clear dentures and we are awaiting information on this subject.

Toronto, Ontario -

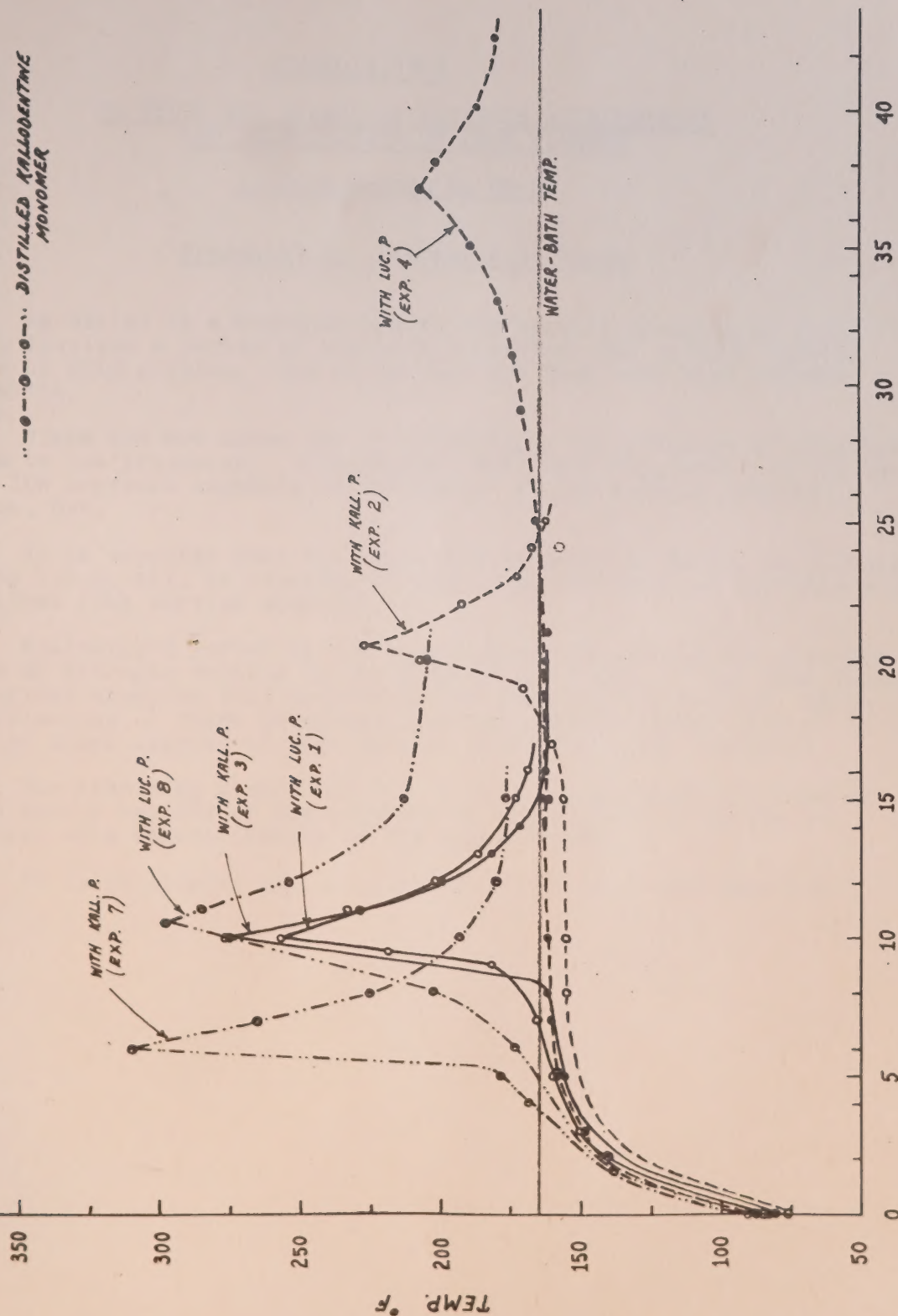
January 9, 1945.

●—○—● DISTILLED MONOMER
■---□---□ UNDISTILLED MONOMER



POLYMERIZATION CURVES FOR MONOMER-POLYMER
MIXTURES OF KALLODENTINE AND LUCITONE

—●— LUCITONE MONOMER
- - -●- - KALLODENTINE MONOMER
· · · -●- · · · DISTILLED KALLODENTINE
MONOMER



APPENDIX " F "

TO STUDY THE EFFECT OF ALTITUDE ACCELERATION
AND DECELERATION ON ORAL TISSUES

Interim Report on DR-6

Presented by Colonel D.S. Coons

As stated in a previous report the initial planning on this project involved a review of existing literature and current investigation of this problem. The review has now been completed insofar as possible.

Plans are now under way to investigate the reaction of gingival tissues to low pressures. Arrangements have been completed for the use of the low pressure chambers and equipment at the R.C.A.F. Station, Eglinton, Ont.

It is expected that the project will start in March. An officer from the C.D.C. will be detailed to supervise the work and patients will be obtained from service sources.

Following a survey of the known investigations of the possible effects of nitrogen bubbles in the pulp of the tooth, it has been decided that further study on this subject is not indicated at present. While the conclusions of other investigations are somewhat indefinite it is felt that other aspects of this project should be given priority.

The remaining studies of D.R. 6 have not yet been outlined or planned mainly because of the pressure of administrative duties in connection with demobilization of the armed forces.

It is considered that a grant-in-aid is still not required.

APPENDIX "G"

Report of Project DR 7

by

Dr. S. Bagnall

"To date I have made liberal extracts from about 450 articles and I have read and discarded as useless somewhere between 2 and 300 other articles. I am of course keeping a full bibliographical record of both the good and the indifferent articles. At present I am working in the decade 1930-1940 and getting the back of that period pretty well broken. I have been disappointed in the absence of much previous attempt to sort out even phases of this voluminous literature, so that this survey is pretty well going to have to be done from scratch. It is true that there were some attempts to survey portions of the literature, but these are mostly either along quite limited lines or deeply colored by the personal bias of the writer. I hope therefore to be well along in the work by the end of the summer. We have finished most of the available German literature, of which very little was of much importance and have started getting micro-film copies of a few of the early and important papers which were not available here. While I am naturally impressed with the need for all possible speed, still I think that the job should be comprehensively done. However there are a few thoughts which I would like to throw out at this time. I think that the bibliography should aim at being quite comprehensive, so that any worker could make use of it. This carries with it two sub-problems. (a) The bibliography which I am for the present calling the "dud" one. That is it lists the articles which are the vague emanations on caries which appear frequently in the literature and do not seem to have any present or likely future use in caries research. So far I have used some and have rejected some. (b) The border line literature, perhaps more particularly where it deals with structure. It is hard to draw any hard and fast line here. The next thought is that the survey should be comprehensive and arranged in some sort of logical format, so that it would be possible to go to it to see what lines of research have been followed. A third point is as to how far it is possible to go in making a critical survey. I see distinct limitations here for any one writer, thus it is possible for me to be critical of certain lines of thought, work, deductions, etc. Then within those broad limits, there is the need for critical comment on procedures, etc. by the specialist, such as the biochemist, bacteriologist, histologist, etc. My own inclination is rather to by-pass that phase and not to attempt to paint the canvas in too great detail. I can see quite a number of avenues which need further work and perhaps after all that is part of our object. One final thought is to the possibility or desirability

of a sectional treatment of the subject. Let me illustrate that by citing this question of Fluorine. It would be possible to pretty well cover that literature ahead of the main project. Such a section cannot stand completely alone, since it is due to some environmental factors of the tooth in the mouth on the other hand, that is the attempt to explain why Fluorine is helpful. I am assuming at this time that it is due to some environmental factor, rather than tooth structure, but of course that opinion may be revised later.

These are just some of the thoughts which are running around in my mind and which you might care to have at this time. One thing I do feel very definitely is that there is a real need for this survey and only hope that I can turn out some sort of a decent job on it."

APPENDIX "H"

MEMORANDUM ON PROJECT DR - 4

by

Major W. J. Linghorne

The project is a study of germicidal and displacement cement packing materials in the treatment of periodontal disease, relating the clinical bacteriologic and histopathologic aspects. It is to be carried on by Dr. H. K. Box and myself, with possibly some assistance from Dr. Best.

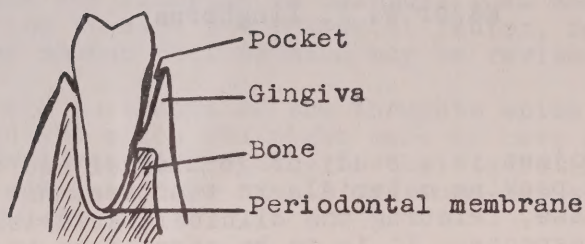
It might be of interest to briefly discuss the significance of this project in the field of dentistry.

The mouth might be considered as a large pocket in which often there are a number of smaller pockets. The interchange between the mouth and these smaller pockets is limited so that their contents differ considerably. The bacterial content of the smaller pockets is much higher, the type of bacteria is different, the pH is not the same, in fact, they must be considered as requiring entirely different management.

The bulk of these smaller pockets are periodontal pockets and deep gingival crevices about partially impacted wisdom teeth.

The view that the tissues of all mouths are exposed to oral bacteria and that the management of infection should be similar, does not therefore seem logical. Where these smaller pockets are present they should be given special treatment. Many studies have indicated that undesirable sequelae frequently occur unless cognizance of this fact is taken. Examples are, bacterial showers in the blood stream following extraction, scaling, or even chewing on periodontally infected teeth, cellulitis and dry sockets.

Outside of the treatment of periodontal disease, sterilization of the field before manipulation where these smaller pockets are present, seems highly desirable.



This sketch shows a tooth, in situ with normal supporting tissues on one side and a periodontal pocket on the other. The conditions around partially erupted third molars is essentially comparable differing only in etiology.

From the histopathology, especially from the studies conducted in our laboratory at The Faculty of Dentistry in Toronto, it would appear that the region where the tissues are being most actively attacked is at the base of the pocket. The maintenance of chemotherapeutic agents in the right place for the required time without their dilution by the fluids of the mouth, presents somewhat of a problem.

A paste that can be placed in the pocket completely filling it, which sets as a cement, has been used with good clinical results. The material will maintain the chemotherapeutic agents in the desired place for the required time, provides an adherent dressing for the affected tissues, also the agents used tend to increase tissue tone.

The use of this type of material has other advantages such as changing the pH of the pocket but I will not go into further detail today. We refer to that type of material as a germicidal cement pack. It would be used to sterilize the field before proceeding with whatever type of treatment is indicated, whether extraction, scaling, gingival surgery or reduction of the pocket by means of a displacement pack.

Displacement packs are used in the service method of treating periodontal disease, for the elimination of the pocket by an outward displacement of the soft tissues. It would appear, from clinical evidence only, that, in certain conditions as when the pockets are not too deep or tortuous and the disease condition is not too acute, the sterilization of the field and the elimination of the pocket might be combined in one operation. While clinical results have been gratifying biopsy sections indicate that chronic inflammatory condition still persists. Whether this can be cleared up by further treatment or if it is a factor tending to cause recurrence, is a subject for further research.

The sketch shows that the bone is lost in advance of the detachment of the tissues from the tooth. Except in rare occasions, this always occurs. Many times the bone is lost to such an extent that the tooth is sitting only in soft tissue. The extent of the loss of bone is the greatest single factor in determining whether the teeth are to be treated or extracted. It is also important in the prognosis. Prevention of bone loss or its restoration, is the goal of the periodontist. I believe most of the dental members will agree with me that so far, success in the restoration of the bony support has been slight. But the work of Box and others indicates it is a possibility. Some of my personal observations tend to confirm my own opinion in this regard. It is thought that bone loss is largely due to toxic absorption and trauma. It seems obvious that the effective elimination of toxic absorption is a prerequisite to bone regeneration. Possibly the use of packing material may be a practical way of accomplishing this.

It would seem then, that the control of infection in these smaller pockets besides being essential in periodontology, is important in many other places of dentistry. The desirability of developing a practical method of handling them, based on scientific investigations, seems to be a worth while project. We hope to provide the clinician, indications for use, directions for using the material and information regarding the results he may expect.

" H-4 "

At present we are experimenting with different materials and techniques for use and establishing criteria. When these are standardized, a study will be planned. In talking this over with Dr. Best last Friday he suggested that a bacteriologist was needed for this project and if the Council would provide \$1000.00 per year he thought he could make one available half time for this work. Dr. Box is also in favour of such a move.

In conclusion I would like to say that periodontal disease of various type is second only to caries in its prevalence. Over one half of the adult teeth lost are due to this type of disease. What is probably more important is the septic condition present for such a long period before the decision to extract. The work in this project offers possibly the most effective and practical approach to an important phase of the treatment of periodontal disease. It is also important in other phases of dentistry and it should be put on a scientific basis.

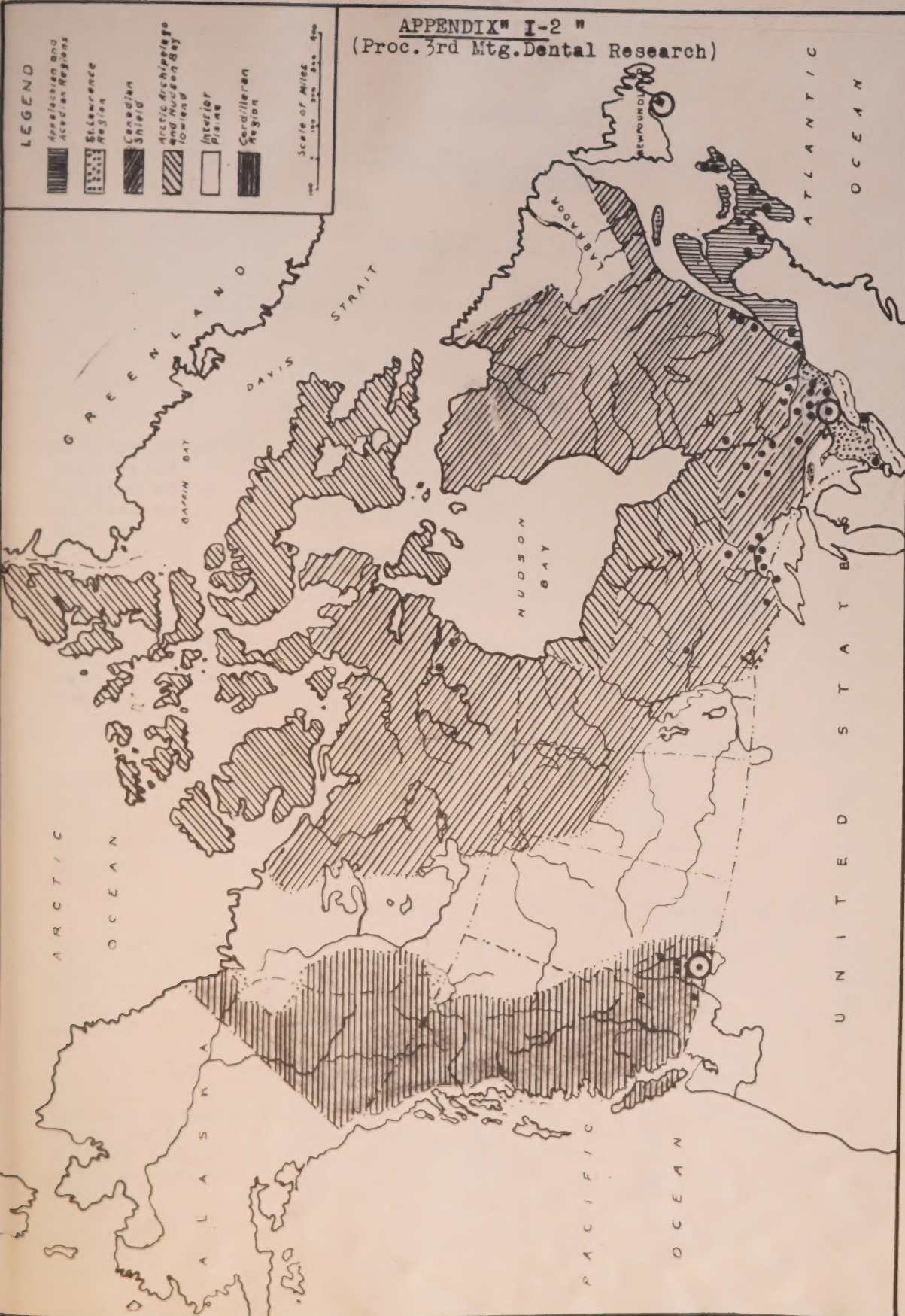
18 February 1946.



FLUORINE IN WATER SUPPLIES

7" PPM LARGE PRINT
7" PPM SMALL PRINT

Date FEB. 11, 1946
D.L.M. HAH



APPENDIX " I-2 "
 (Proc. 3rd Mtg. Dental Research)

GEOLOGICAL SURVEY OF CANADA
 ECONOMIC GEOLOGY SERIES No. 6
 M. E. WILSON - 1929.

Fluorspar Deposits of Canada
 MAP BY JOHN A. M. DAWSON FEB. 1946.

FLUORSPAR DEPOSIT •
 FLUORSPAR MINES ◎

<u>Total samples examined</u>	<u>0.9 p.p.m. and over of fluorine</u>	<u>Less than 0.9 p.p.m. of fluorine</u>	<u>Per cent of 0.9 p.p.m. and over</u>
---------------------------------------	--	---	--

(6) East Central Area - Low Fluorine Region

Samples of water	250	14	236	5.6
Deep wells	46	7	39	15.2
Shallow wells	129	3	126	2.3
Surface waters	4	0	4	0
Unknown	71	4	67	5.6

(7) Coronation Area - Medium Fluorine Region

Samples of water	40	5	35	12.5
Deep wells	10	4	6	40.0
Shallow wells	17	1	16	5.9
Surface waters	1	0	1	0
Unknown	12	0	12	0

(8) Southeastern Area - Low Fluorine Region

Samples of water	112	9	103	8.0
Deep wells	31	3	28	9.7
Shallow wells	37	4	33	10.8
Surface waters	6	0	6	0
Unknown	38	2	36	5.3

Summary

Samples of water	1015	181	834	17.9
Deep wells	271	113	158	41.7
Shallow wells	399	30	369	7.5
Surface waters	61	3	58	4.9
Unknown	284	35	249	12.3

INITIAL DISTRIBUTION

1. Dr. R. G. Ellis, Chairman
2. President C. J. Mackenzie (ex-officio)

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3. Dr. H. K. Box
4. Dr. G. D. Stibbs
5. Dr. H. R. MacLean
6. Dr. M. H. Garvin
7. Dr. E. Charron

Rep. Army Dental Corps

8. Col. D. S. Coons
9. Major W. J. Linghorne

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10. Dr. E. F. Burton
11. Dr. J. B. Collip
12. Dr. A. R. Gordon
13. Surg. Capt. C. H. Best
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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
FIRST MEETING
OF THE
EXECUTIVE
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

27 MARCH, 1946

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Appendices

- A - Fluorine-Caries Control Study at Marshall and Jacksonville, Texas, U.S.A.
- B - Fluorine as an Inhibitor of Dental Decay
- C - A Comparative Study of the Influence of Fluorides in Drinking Water on Dental Decay (Reprint from the Journal of the Wisconsin State Dental Society September-October 1945)
- D - Lectures presented at the Inservice Training Course for Water-works Personnel 22-4 May 1945 (This document is recorded as Appendix "D" and is being published separately as a supplement to these proceedings for distribution to the members).
- E - Draft of a descriptive pamphlet containing general information regarding the interest and activities of the Associate Committee on Dental Research.

Proceedings of the First Meeting
of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber

NATIONAL RESEARCH BUILDING

1:30 p.m., Wednesday, 27 March 1946.

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. D. L. Thomson

Mr. S. J. Cook, Secretary

Apologies for their absence were received from
Dr. E. Charron and Col. D. S. Coons.

2. Proceedings

THE CHAIRMAN explained that he had not known until yesterday of the enforced absence of Dr. Charron. Col. Coons regretted that he could not be at the meeting, being away from Ottawa at this time on an inspection trip. He thought, however, the business of the Executive might be taken up by the members present and a draft of the proceedings submitted to the absent members for their consideration. AGREED.

(In accordance with this arrangement, copies of the draft proceedings were submitted to Col. Coons and Dr. Charron who suggested minor changes. With these corrections the proceedings have been approved by them.)

3. Business Arising from the Minutes of the 3rd Meeting of the Committee

(i) (3rd Mtg. Min. 5 (vii)) THE CHAIRMAN reported that he had written to Dr. Bagnall asking him to proceed in accordance with the instructions laid down by the Committee.

(ii) (3rd Mtg. Min. 7 (iii)) THE CHAIRMAN reported that no application had yet been received under item DR 4.

(iii) (3rd Mtg. Min. 7(v)) THE SECRETARY presented an application from Major R. L. Twible for \$4,800. for 1946-47. This grant had been previously approved pending receipt of an application.

(iv) (3rd Mtg. Min. 10) THE CHAIRMAN reported that he had taken the action desired in regard to a letter to Dr. Bagnall.

4. Application for Grant-in-Aid

THE CHAIRMAN presented an application from Dr. George Miller Macdonald for a grant-in-aid on Facial Prostheses in the amount of \$800. He said that this application had originally been presented at the 9th Meeting of the Associate Committee on Army Medical Research but that that Committee had considered the application to be one that should be dealt with by the Associate Committee on Dental Research in as much as the work was to be done by a specialist dental surgeon and the experimental work on processing and application of facial prostheses from various plastic materials would be very largely a problem in dentistry.

It was recommended that the grant be designated DR 10 and APPROVED.

5. Fluorine as Related to Teeth (3rd Mtg. Min. 8)

THE CHAIRMAN reported that he had succeeded in securing a number of reprints and a manuscript relating to the subject of fluorine and he suggested that these be included as appendices to the proceedings of this Meeting.

These reports are as follows:

- (i) Fluorine Caries Control Study at Marshall and Jacksonville, Texas, U.S.A. (APPENDIX "A")
- (ii) Fluorine as an Inhibitor of Dental Decay by John G. Frisch (Reprinted from the Journal of the Wisconsin State Dental Society November-December 1944) (APPENDIX "B")
- (iii) Reprint from the Journal of the Wisconsin State Dental Society September-October 1945 entitled "A Comparative Study of the Influence of Fluorides in Drinking Water on Dental Decay" by John G. Frisch. (APPENDIX "C")
- (iv) THE CHAIRMAN said that he had also obtained a report from Ann Arbor, Michigan entitled "Lectures presented at the Inservice Training Course for Waterworks Personnel 22-4 May 1945". This publication contained about 50 pages of material relating to the subject of fluorine and teeth and the Chairman proposed that an effort be made to secure enough copies for distribution to the members of the Dental Committee or alternatively that the 50 pages referred to be reproduced and published as an Appendix to the proceedings of this Meeting. This document is recorded as Appendix "D" and is being published separately as a supplement to these proceedings for distribution to the members. (APPENDIX "D")

as a coordinator in the work if its services were required. The Chairman stated that he thought the Department would follow up on this problem. It had been pointed out to him that the Dominion Department of National Health and Welfare would be unable to initiate work within the province and it would be necessary therefore to secure support from the provincial authorities for specific problems. It was suggested that Dr. Janes might go to Toronto to consult the Ontario authorities and ascertain what arrangements could be made to carry out this programme in Ontario as a sample. Dr. Janes might then be invited to attend the next meeting of the Associate Committee on Dental Research to report the results of his interview with the Ontario authorities.

DR. THOMSON inquired whether it was proposed to follow up the investigations that had already been carried out by the Chairman under DR 8 in Brantford.

THE CHAIRMAN replied that he hoped it might be possible to carry out similar studies in Stratford in the autumn after a report had been received from the Department of National Health and Welfare as to their participation in the programme.

8. Preparation of Descriptive Pamphlet (3rd Mtg. Min. 6 page 6)

THE CHAIRMAN submitted a draft of a descriptive pamphlet containing general information regarding the interest and activities of the Associate Committee on Dental Research. This Draft was considered in detail and numerous changes were made in it. A copy of the revised draft appears as Appendix "E".

APPENDIX "E"

9. Mailing List for Descriptive Pamphlet

The following distribution for the descriptive pamphlet was suggested:

(i) University Departments of Anatomy, Bacteriology, Biochemistry, Chemistry, Chemical Engineering, Dentistry, Histology, Medicine, Metallurgy, Nutrition, Pharmacology, Physics, Physiology, Zoology. *Hygiene*

(ii) Provincial Dental Registries. *Public Health*

(iii) Dominion Dental Council *Health*

(iv) Canadian Dental Association Journal *Food Chemistry*

(v) Oral Health

(vi) Canadian Medical Journal

- (vii) Journal of American Dental Association
- (viii) Journal of International Dental Research
- (ix) Science
- (x) Journals in Canada such as Canadian Chemistry and Process Industries, Canadian Business, Industrial Canada, etc.

VI University Hospitals.

Meeting adjourned at 5 p.m.

APPENDIX "A"

FLUORINE-CARIES CONTROL STUDY AT MARSHALL AND JACKSONVILLE, TEXAS, U.S.A.

Through a joint cooperative plan between the Texas State Department of Health and the city of Marshall, Texas, a study will be conducted over a period of ten or twelve years to determine the relationship between artificial fluorination of water and dental caries. Fluorine will be added to the city water supply to a concentration of one part per million, and the incidence of dental decay will be checked before the experiment begins and periodically thereafter for comparison. Jacksonville, Texas, with a fluorine free water supply will be used as a control throughout the ten or twelve year period. This city has agreed to maintain a fluorine free water supply and the incidence or increment of dental caries will be checked there simultaneously with Marshall and among similar groups to those used in Marshall.

Dental caries is one of, if not the greatest, problem confronting dentistry. The increment of it alone is in excess to our dental manpower ability, to say nothing of the enormous backlog. Certainly, there is no other group as cognizant of this problem as is the dental profession; and many times we have been subjected to the slurs of the jesters and ridiculers when they accuse us of not even knowing the etiology of this, the most prevalent disease of man. Public health is very much on the spot when we claim to have a program of prevention, and when we have to admit that with our present knowledge and facilities we cannot even control the increment.

From studies made by Klein, Palmerl and others, we learn that we are faced with the following factual circumstances which account for the seemingly insurmountable dental-caries problem.

1. Dental caries is practically universal, regardless of age, sex, race, or economic status.

2. Dental caries is a progressive disease and, unless corrected through surgical procedure, ultimately leads to the loss of the affected teeth.

3. Diseased teeth and their investing tissues may become foci or infection.

4. Because of the widespread prevalence of this disease and the inadequacy of present-day methods to control it, dental caries is a public health problem and should be treated as such. This calls for its study along broad epidemiological lines, and its control by the application of means which can and will reach large masses of the population.

Justification--Numerous surveys of the incidence of dental caries in hundreds of communities with varying concentrations

of fluorine have definitely and thoroughly convinced all students that the incidence of dental caries is inversely proportionate to the concentration of fluorine in the communal water supply, or let me qualify that statement by saying that such is the case up to a certain concentration point. Surveys made by the United States Public Health Service by Dr. H. T. Dean and his co-workers, in which 21 cities were studied and 7,257 white, urban, native school children, age 12 to 14 years were examined, revealed a convincing and indisputable conclusion that where the water supply contained approximately one part per million fluorine, the incidence of dental caries was only from less than one-half to one-third as high as in communities having fluorine free water. Numerous other surveys have told very much the same story.

Our studies in Deaf Smith County offer another striking example. It is, however, a well known fact that the use of waters with a fluorine concentration considerably above one part per million is apt to produce fluorosis (mottled enamel) in the permanent teeth of children using the water during the formative period of the permanent teeth, or from birth to eight years of age. Since it appears that the inhibition to dental caries is almost as great where the water is approximately 1 p.p.m. F as it is with higher concentrations, that point of concentration (1 p.p.m.F.) has been almost universally accepted as the optimal concentration. So nearly has 1 p.p.m.F. been established and accepted as optimum, that the Research Commission of the American Dental Association has published the following statement: "We are, therefore, in a position to state that the natural occurrence of 1 p.p.m. of F. in a water supply is desirable for the development of caries-resisting teeth."

While we must accept 1 p.p.m.F. occurring naturally in the water as being desirable and while it seems logical to assume that by the ingestion of sodium fluoride into fluorine free water sufficient to bring the fluorine concentration up to 1 p.p.m. will produce the same results, it remains to be proven that it will, and that there will be no harmful effects to the organism from its continuous use.

It should be borne in mind that the lethal dose of sodium fluoride is four grams. On the assumption, based on the best authorities, that an adult daily consumes about one and one-half to two liters of water made up of potable water and water added to food in the cooking process; it would be necessary, in order to obtain a lethal dose, for an individual to consume approximately 2,000 liters or 500 gallons of water. Furthermore, it is well known that many communities have been using natural concentrations as high as six to eight and even ten parts per million for many years with no apparent harmful results other than the mottling of the enamel. It is well known according to McClure⁴ that excessive fluorine is eliminated by excretion at a sufficient rate to obviate danger of an objectionable cumulative effect. We therefore assume

that the addition of 1 p.p.m.F. to the fluorine free water is absolutely many times within the range of safety.

The Approach at Marshall--Upon the suggestion of one of the dentists of Marshall and upon an invitation from the local dentists, the Chamber of Commerce and the City Government, a visit was made to Marshall, and negotiations were begun towards planning for a research study by ingesting 1 p.p.m.F. by the use of sodium fluoride into the city water supply for a period of ten or twelve years. At a later date a meeting was held, composed of representatives of the dental and medical professions, the City Government, the public schools and other groups, at which time the plan was fully explained. One week later notice was received by the State Health Officer from the Mayor of Marshall, stating that the plan has been unanimously approved by the City Commission and that adequate funds were being appropriated for defraying the cost. Briefly, the plan is as follows:

At Jacksonville-- In order to accurately measure the results of the water treatment at Marshall it becomes necessary that some comparable city with fluorine free water to be used as a control. Jacksonville was selected and was asked to agree to maintain fluorine free water throughout the period of the study. Through the magnanimity and generous cooperation of the dentists, physicians, City Government, Chamber of Commerce and public schools such an agreement was readily entered into. Jacksonville should be given due credit and applause for this philanthropic gesture since to be sure it has nothing to gain by such an agreement and submits itself to the possibility of being penalized by it. Written agreements for both Marshall and Jacksonville were drawn up and signed by Dr. George W. Cox, State Health Officer, and the Mayor and members of the City Commission and City Manager in both cities.

The Plan--1. It is to be a joint cooperative plan between the State Department of Health and the city of Marshall.

2. It is distinctly understood that no promises are made by the State Health Department as to the results of the experiment.

3. The State Department of Health will make regular periodical and careful examinations of native-born continuous history children using the water supply, from first grade through the sophomore class of high school in the beginning, and later through the senior class at high school. These examinations will be based on the DMF rate (DMF meaning decayed, missing, and filled teeth). They will be made with mouth mirror and explorer and carefully charted. X-Ray examinations on a cross section of the children will be made for estimating the efficiency of the mouth

*Fluorine As An Inhibitor
of Dental Decay*

BY

John G. Frisch

Reprint from THE JOURNAL OF THE WISCONSIN STATE DENTAL SOCIETY
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Fluorine As An Inhibitor of Dental Decay

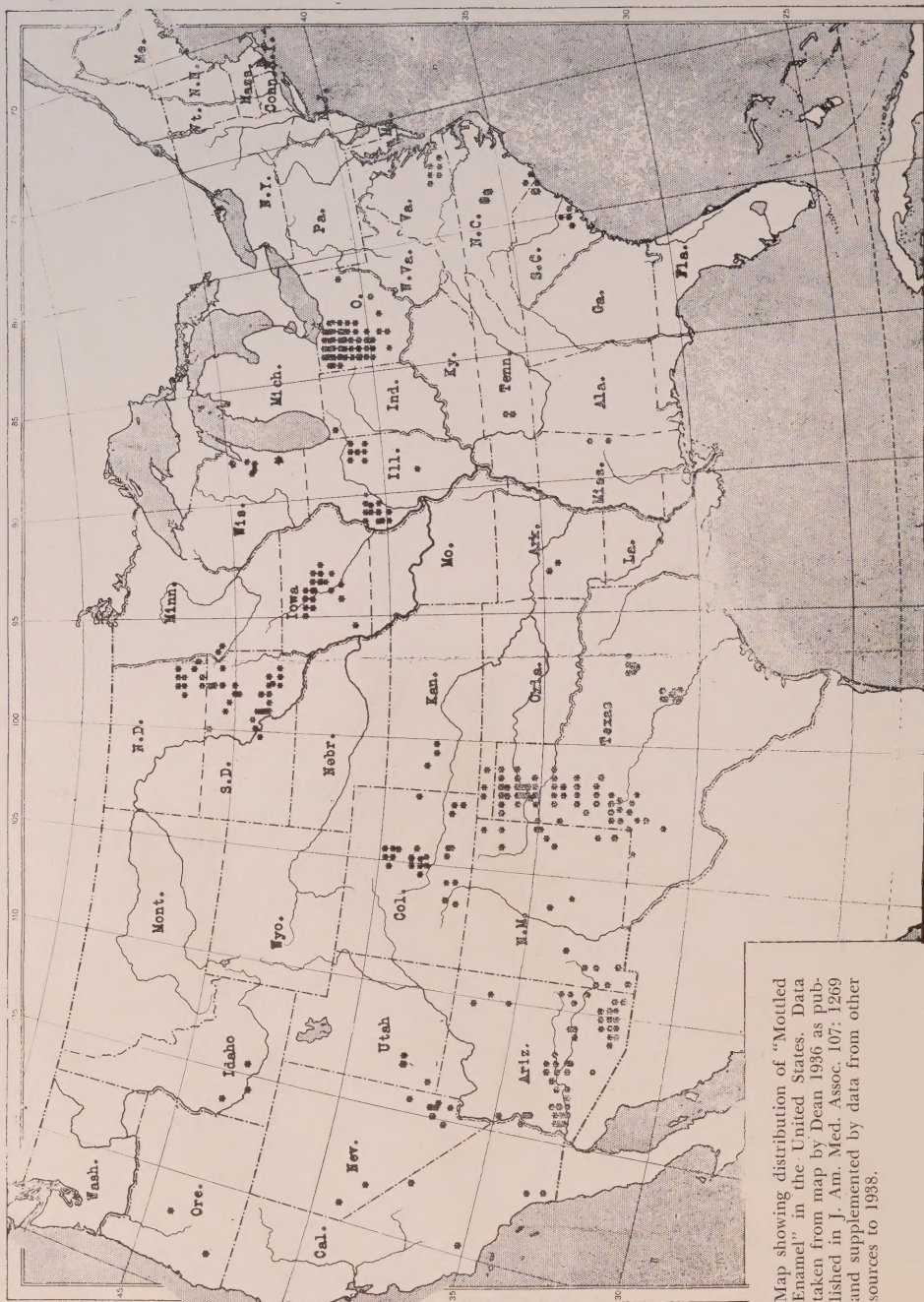
JOHN G. FRISCH, D.D.S., Madison, Wis.

THE "curious absence of decay" was noted by Black and McKay in endemic mottled enamel areas, in 1916. Fluorine was found to be the causative factor in the production of the mottling of teeth, in 1931. In any history of the fluorine-caries relationship, the 1937-1939 period will be conspicuous. It was during these years that epidemiological studies were first made in areas of endemic dental fluorosis. These surveys showed that there was a marked reduction in dental caries even when the fluorine concentration did not approach the mottling level. The strikingly low occurrence of dental caries in areas where fluorine is present in the water supply is now a well recognized clinical phenomenon.

There looms on the horizon a new and intriguing method of assault on the hitherto baffling problem of tooth decay. The dental and medical professions have

become cognizant of the potentialities of fluorine and there are sound reasons and high hopes that the enigma of dental caries may be largely controlled through mass attack via public water supplies. The overwhelming weight of the evidence indicates that fluorine should be added to water in areas of fluorine deficiency. There is no evidence that the controlled optimum of 1 part per million is in any way harmful to communal health.

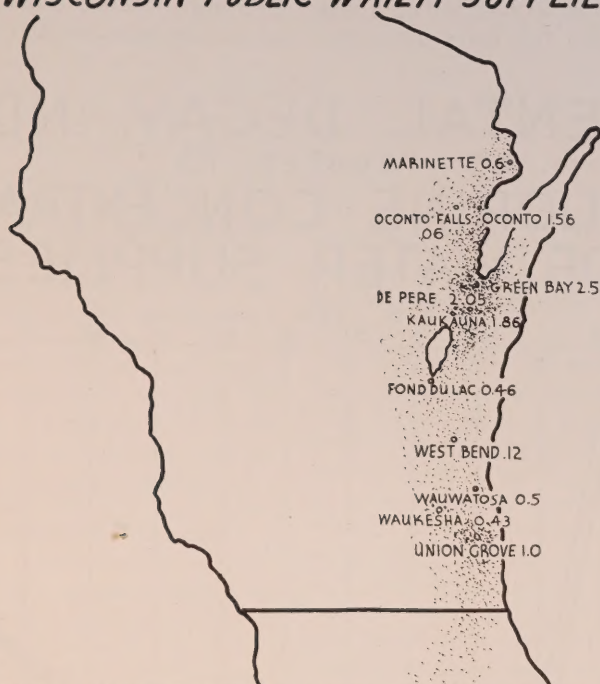
The professions of dentistry and medicine must admit that, up to now, we have failed miserably in effecting any appreciable reduction in the incidence of dental caries. Our program has been, chiefly, the improving of nutrition and hygiene. Here and there, and to a degree, a faithful individual has benefited from the regimen. There has been no sharp decrease but rather an increase in dental



Map showing distribution of "Mottled Enamel" in the United States. Data taken from map by Dean 1936 as published in J. Am. Med. Assoc. 107: 1269 and supplemented by data from other sources to 1938.

FLUORINE CONCENTRATIONS

IN WISCONSIN PUBLIC WATER SUPPLIES



WISCONSIN MUNICIPALITIES WITH 0.5 P.P.M. OR ABOVE

NOTE: IT IS CONSIDERED THAT CONCENTRATIONS BELOW 0.5 ARE NOT SUFFICIENT TO MATERIALLY REDUCE CARIES ACTIVITY...

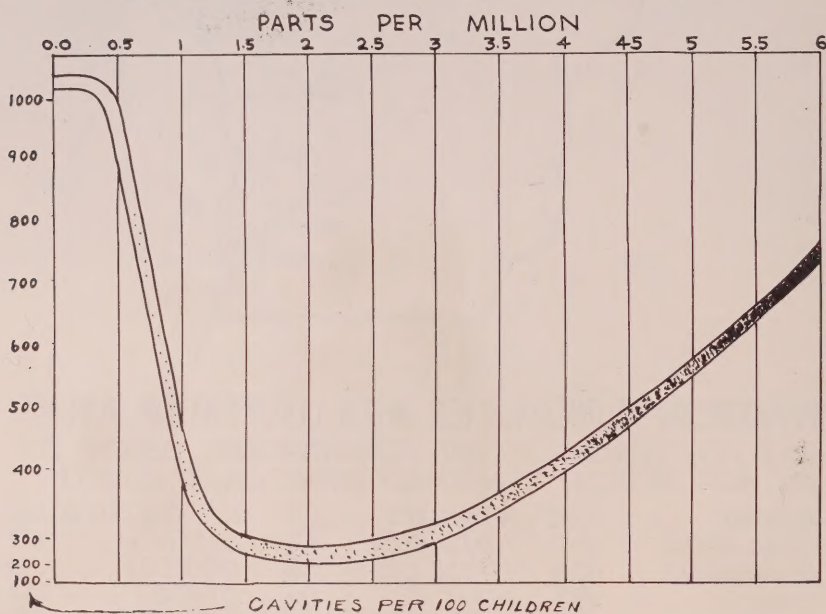
ALGOMA	0.52	KEWAUNEE	0.7	NO. FOND DU LAC	0.6
CEDAR GROVE	0.5	KIMBERLEY	1.2	OAKFIELD	0.7
CLINTONVILLE	0.6	LITTLE CHUTE	1.85	OCONTO	1.56
CORNELL	0.7	LOYAL	0.6	OSSEO	0.7
CUDAHY	0.5	MARINETTE	0.6	RIB LAKE	0.6
DE PERE	2.05	MARION	0.6	SPRING GREEN	0.5
FOOTVILLE	1.0	MERRILL	0.6	STEVENS PT.	0.7
GLEN HAVEN	0.6	MONTICELLO	0.5	STURTEVANT	0.85
GRAFTON	0.5	MONTREAL	0.6	THORP	0.65
GREEN BAY	2.5	MT. HOREB	0.65	TWIN LAKES	0.6
HURLEY	0.5	MUKWONAGO	0.5	UNION GROVE	1.0
KAUKAUNA	1.86	NEKOOSA	0.6	WAUWATOSA	0.5

decay among the masses of the people. Diets have been worked out that will somewhat control decay but with this program, the public will not co-operate. People would rather have bad teeth than eat spinach and only under compulsion

man body and must take its place at the top of the list of public health problems.

Recent studies on various aspects of dental decay lends further support to the theory that the destruction of the enamel and then the dentine is caused

DENTAL DECAY INDEX AS RELATES TO FLUORINE CONCENTRATION OF WATER SUPPLIES



will they forego the things they like to eat regardless of the effect on their teeth. After a decade of effort to improve teeth by diet and conventional prophylaxis, numerous independent surveys of school children give no indication of a decrease in caries. Dental decay still remains the most prevalent of all defects of the hu-

man body and must take its place at the top of the list of public health problems. A variety of local and systemic conditions may modify the speed of tooth destruction, but aside from the action of acids, no mechanism for dental decay has yet been demonstrated.* The resistance to caries must come from either the tooth substance itself, which must be more

resistant to the action of acids, or from some local condition which operates to reduce acid production in the immediate vicinity of the enamel.

Armstrong, University of Minnesota, has demonstrated that the enamel of caries resistant teeth has 0.0111 mg. against 0.0069 mg. of fluorine for caries susceptible teeth, an increase of about 40%. The dentine shows only a negligible difference of 0.0169 mg. as against 0.0158 mg. fluorine per 100 cubic centimeters. McClure and Elvove in U. S. Public Health Service reprint #2073, report that the use of a domestic water of 1.0 to 1.8 p.p.m. fluorine concentration was associated with unusually low lactobacillus counts. The research at Michigan and Northwestern Universities has established that there is a definite ratio between high lactobacillus counts and a high caries rate. Fluorine water seems to operate systemically to produce a more resistant enamel and locally to reduce lactobacillus activity. Animal research by Cheyne, University of Iowa, establishes the hypothesis that dietary fluorine is absorbed in the intestinal tract, carried to the salivary glands through the blood stream, and secreted in the saliva in amounts sufficient to inhibit decay. A constant protective circle is established as the saliva is swallowed and again and again absorbed and redistributed to the oral cavity by the salivary glands. Bibby, University of Rochester, believes that fluorine may combine with the enamel through local contact. He also maintains that in fluoride therapy, the factors operating after tooth formation are more important than those operating before the tooth has erupted. He calls attention to the fact that the caries index of the upper incisors in the fluoride areas is 15 to 19 times less than in the nonfluoride areas;

compared to a reduction of only 4 times less of caries experience in the molar region. He attributes this phenomenon to the fact that in drinking fluorine water, the upper incisors are bathed in such water in about the same comparative ratio to the molar areas as the caries reduction rate indicates. In all surveys to date, the amount of caries inhibition seems to be in direct proportion to the length of time that the individual has used fluoride water. The born and reared child benefits most, but the person who moves into the fluoride area after the calcification of the teeth is also definitely benefited.

In the U.S., there are about 400 areas where fluorides occur naturally in the water supply, in these regions surface waters are comparatively free of fluorine, but deep wells in the endemic areas are the source of fluorine containing waters. Upwards of 10,000,000 (estimated) people are daily using this water. Many of these areas are in our immediate neighborhood, in Wisconsin and northern Illinois. Dental caries surveys in relation to fluoride content of public water supplies have been made in 23 cities of 5 states on a total of 11,302 children in the 12-14 age group. The state departments of health of Wisconsin and Illinois and the U. S. Public Health Dept. have made surveys whose findings show the condition of the teeth in non-fluorine areas is pathetic and alarming. The surveys also show a startling decrease in caries activity among children in the fluoride areas.

In every break down of caries experience, the child born and reared in a fluoride area has a tremendous advantage. Chance alone cannot explain why 30 children out of every 100 up to age 15 in Green Bay (2.5 p.p.m.) have never had a cavity, to Sheboygan's (0.0 p.p.m.) less than 3; why Sheboygan has 15 times as

SUMMARY OF COMPLETE DENTAL SURVEY

GREEN BAY and SHEBOYGAN

FRANCIS A. BULL... WISCONSIN STATE HEALTH DEPT. J.A.D.A. AUG. 1943

AGE 12 TO 14

	NUMBER OF CHILDREN EXAMINED	NUMBER OF TEETH FILLED	ANTERIORES FILLED	ANTERIOR SURFACES FILLED	CARIOUS TEETH	ANTERIOR CARIOUS TEETH	ANTERIOR SURFACES CARIOUS	EXTRACTED	NEED EXTRACTION	FIRST MOLARS FILLED	FIRST MOLARS CARIOUS	FIRST MOLARS EXTRACTED	FIRST MOLARS NEED EXTRACTION	D.M.F.
GREEN BAY BORN	1647	2729	104	105	1343	107	122	236	65	2125	817	179	74	2.62
BORN OUTSIDE GREEN BAY	521	1472	112	123	732	95	99	187	58	917	372	144	72	4.59
TOTAL GREEN BAY	2168	4201	216	228	2075	202	221	423	123	3102	1189	323	146	3.06
TOTAL SHEBOYGAN	1877	11,993	7282	7699	2754	853	962	1787	206	5139	510	1054	196	8.54

GREEN BAY
★ 7.5 F. PAIRED PER MILLION

SHEBOYGAN
★ 6.0 F. PAIRED PER MILLION

D.M.F. (DECAY, MISSING and FILLED) is determined by adding the number of filled teeth, the number of carious teeth, and the number of missing teeth, presumably because of caries; and dividing this total by the number of children examined

PERCENTAGE TABLE OF CARIES EXPERIENCE

GREEN BAY 2.5 FLUORINE PARTS PER MILLION

SHEBOYGAN 0.0 FLUORINE PARTS PER MILLION

FRANCIS A. BULL . . . WISCONSIN STATE HEALTH DEPT J. A. D. A. AUGUST 1943

	NO CARIES	ONE CARIES	TWO CARIES	TWO OR LESS	OVER TWO
GREEN BAY BORN	 29.8	 10.7	 14.6	 55.1	 44.9
BORN OUTSIDE GREEN BAY	 10.9	 7.7	 7.7	 76.3	 73.7
GREEN BAY	 25.3	 10.0	 12.9	 48.7	 51.8
SHEBOYGAN	 2.77	 2.34	 2.82	 7.93	 92.07

GENERAL SUMMARY OF RESULTS

	GREEN BAY	SHEBOYGAN
1. NO CARIES BORN AND REARED IN CITY	 30%	 3%
2. TWO OR LESS CARIES BORN AND REARED IN CITY	 55%	 8%
3. FIRST MOLARS DEVELOPING CARIES		 2 TIMES AS MANY AS GREEN BAY
4. TEETH EXTRACTIONS		 5 TIMES AS MANY AS GREEN BAY
5. DECAY OF ANTERIOR TEETH		 16 TIMES AS MANY AS GREEN BAY
6. NUMBER OF FILLINGS		 4 TIMES AS MANY AS GREEN BAY
7. ABOUT 70% LOWER OVER ALL CARIES EXPERIENCE IN GREEN BAY BORN		

much decay of the anterior teeth as does Green Bay; why Green Bay has a 70% lower over all caries rate than Sheboygan. Chance alone cannot explain why 25 children in Aurora (1.2 p.p.m.), 29 in Maywood (1.4 p.p.m.), 25 in Elmhurst (1.5 p.p.m.) out of every 100 examined have never had a cavity. Nor can chance alone explain why Maywood (1.4 p.p.m.) which is only one mile from Oak Park (0.0 p.p.m.) has a caries experience 65% lower than Oak Park. (Note. Maywood gets its water from deep wells; Oak Park buys its water from Chicago which gets it from Lake Michigan.) Dean has remarked that he could go into a town, analyze its water supply and tell you whether or not a dentist could make a living there.

A supporting bit of evidence to the contention that decay is on the increase in each succeeding generation can be gleaned from the fact the average sum total of dental caries experience (D.M.F.) in the non fluorine areas of the "Selectee Chart" (10.7) is less in the age group 21 to 37 than the average D.M.F. rate of 12.3 and 14.6 in the Aurora, Oak Park, Waukegan chart in the 12-14 age group.

Fluorine, like many other chemicals, has a definite value in controlled dosage. We know that with a fluorine free water we have a high caries rate; we know that with a high fluorine content we have produced unsightly mottled enamel; somewhere in between is the optimum level that will inhibit decay without producing any untoward results. Elvove, senior chemist, U. S. Health Dept. concludes that if the fluorine concentration is below 0.5 p.p.m. little or no caries inhibition takes place but as the concentration approaches 0.5 p.p.m. dental decay is inhibited progressively as the water supply reaches 1.5 p.p.m. that caries reduction levels off at 1.5 and as the con-

centration goes up from that point, mottling with brown stain appears and caries increases. Animal experimentation with comparatively high dosages has produced toxic manifestations, but these experiments do not demonstrate any pathology beyond the mottling of enamel in the human population. Dean, J.A.M.A. 107-1936, states that the genetic dental tissue is electively sensitive to fluorine and that the osseous tissue is affected only at much higher concentrations. U. S. Public Health reports indicate that mottling occurs in about 9% of children when the fluoride content was as low as 1 p.p.m., but that this condition was only in the mildest forms of dental fluorosis, of no esthetic significance, recognizable only, in many cases by the trained observer. Mottling is progressively intensified from a very mild form in 9% of children in fluorine water concentrations of 1 p.p.m. to a mild or severe and destructive fluorosis in 100% of the children when the concentration reaches 6 p.p.m. Mottling occurs only when the individual has used fluorides of a high concentration during the calcification period (first eight years of life). Controlled dosage is preferable to a reliance upon natural concentrations which may vary from time to time as the water seeps through sediment of inconstant mass and solubility.

Nowhere is there a public health problem with fluorine water except for mottled enamel. This occurs only when the concentration of such waters is greater than 1 p.p.m. Gaud, Charnot, and L'Anglais in connection with surveys made in North Africa (Bulletin Inst. of Hygiene 1934) declare "It is to be noted that if, with mottled enamel, there has been produced in man serious general phenomenon, disturbances in the function of reproduction, and an abnormal infant

COMPARATIVE DENTAL CARIES EXPERIENCE

IN CHILDREN 12-14 BORN and REARED
IN FLUORINE and NON-FLUORINE AREAS

PERMANENT TEETH - BODECKER - DEAN - U.S. PUBLIC HEALTH SURVEY 1938

NUMBER OF DENTAL CARIES EXPERIENCES DECAYED MISSING or FILLED	AURORA 1 2 F PARTS PER MILLION		OAK PARK 0 0 F PARTS PER MILLION		WAUKEGAN 0 0 F PARTS PER MILLION	
	NUMBER OF CHILDREN	PERCENTAGE OF TOTAL EXAMINED	NUMBER OF CHILDREN	PERCENTAGE OF TOTAL EXAMINED	NUMBER OF CHILDREN	PERCENTAGE OF TOTAL EXAMINED
0	85	25.0	6	2.9	6	2.6
1	37	10.9	2	1.0	5	2.2
2	39	11.5	5	2.4	7	3.1
3	26	7.6	9	4.3	5	2.2
4	31	9.1	8	3.8	10	4.4
5	20	5.9	9	4.3	6	2.6
6	23	6.8	10	4.8	4	1.8
7	18	5.3	14	6.7	8	3.5
8	18	5.3	14	6.7	11	4.8
9	8	2.3	9	4.3	11	4.8
10	9	2.6	16	7.7	12	5.2
11	7	2.1	13	6.3	9	3.9
12	7	2.1	12	5.8	12	5.2
13	3	0.9	14	6.7	9	3.9
14	2	0.6	11	5.3	11	4.8
15	1	0.3	7	3.4	10	4.4
16	0	0.0	3	1.4	11	4.8
17	1	0.3	5	2.4	9	3.9
18	2	0.6	3	1.4	10	4.4
19	1	0.3	7	3.4	6	2.6
20	2	0.6	31	15.0	57	24.9
AVERAGE CARIES INDEX 1938 BASED UPON EXAMINED	4.0		12.3		14.6	

SUMMARY of AURORA, OAK PARK, WAUKEGAN SURVEY 12-14

1. Aurora (1.2 P.P.M.) has NINE TIMES as many children per 100 who have had no caries experience
2. About 60% LOWER over all dental caries experiences
3. Almost 75% DECREASE in first permanent molar loss
4. Approximately 95% LESS caries of the four upper incisors
5. Bodecker Caries Index of about 3/4 times less in Aurora only 845 or 5.1% out of a total of 16,448 permanent teeth were diagnosed as mottled. 0.3% of which were incisors. In no instance was diagnosis of moderate or Brown Stain or severe fluorosis made. In view of these results, the slight amount and very mild degree of dental fluorosis resulting from a concentration of 1 P.P.M.F. cannot be considered objectionable, and there is an unlikelihood of any other toxic manifestations.

DR. J. O. FRISCH, MADISON, WISCONSIN
STATE FLUORINE COMMITTEE

mortality, the population of these regions would have been affected. But the density of the population in these regions and the physical condition of the individuals do not confirm this hypothesis. Pathological manifestations in areas with fluorine content of 2 to 3 p.p.m. in man is limited clinically to dental dysmorphies." There are no pathologies reported resulting from the ingestion of fluoride water and the health authorities in the fluorine areas know of no general pathology associated with their drinking water. At a meeting of the Dane County Dental Society in May 1944, Dr. C. N. Neupert, Wisconsin's State Health Officer, said that he had no reports of pathologies associated with drinking water in the fluorine areas of Wisconsin. Dr. H. T. Dean, U. S. Public Health Service, at a meeting of the Research Commission of the A.D.A. in Chicago on October 17, 1944 made the following statement, "I am not in the least worried about pathologies in concentrations of 1 part per million." One city, Newburgh, N. Y. (pop. 32,000) has already fortified its deficient water supply with fluorides to the concentration of 1 p.p.m. Another city, Grand Rapids, Mich. (pop. 165,000) has received permission from the U. S. Dept. of Public Health to raise artificially, the fluorine level of its water supply to 1 p.p.m. The dentists in that community are now making a very complete survey of dental caries; equipment is being installed, and it is expected that this project will be in operation by January 1, 1945. One other city, Escanaba, Mich., has changed its water supply from fluorine free Lake Michigan to deep well water with a fluoride content of 0.5 p.p.m.

The skeptic contends that the evidence is only presumptive and because no pathologies have been reported, it does not

follow that none exist. Millions of people have used fluoride water for generations; population shifts between non-fluorine and fluorine areas have been continuous and yet no ill effects have been observed even in some areas in the U. S. (Bauxite, Ark.) where the concentration was as high as 14 p.p.m. In the final analysis, the value of any substance in the cure or amelioration of disease must be predicated upon an appraisal of its advantages and disadvantages. On the one hand there is the disadvantage of a slight mottling in 9% of the children; on the other hand, there is a theoretical reduction of dental caries of 65%, and a proportionate reduction in the relative incidence of a long list of pathologies that have their etiology in dental foci and a host of other pathologies that result directly or indirectly from the decay of teeth. We need not reach the consummate in any course of action and if the results obtained will be definitely beneficial, we should make our findings known.

Hardness of the water is not a factor in caries reduction because there are both hard waters (more than 150 p.p.m.) and soft waters (less than 150 p.p.m.) in the high caries rate group of cities surveyed and also hard and soft waters in the low caries rate groups. It is quite generally agreed that fluorine in water is the inhibiting factor in dental caries and that we need have no fear of any pathologies in 1 part per million. Some persons are doubtful as to whether it will work if a deficiency of fluorine is supplied as it does when the water contains a "natural" quantity of fluorides. It should be borne in mind that the so called "natural" waters got their fluorine by dissolving it out of fluorine bearing rock in the strata of the earth. These very same waters contained no fluorine until they



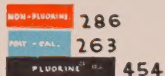
SUMMARY OF DENTAL CARIES EXPERIENCE

1003 ILLINOIS SELECTEES
AGE 21-37

Computations Based
On Per 100 Examined
(THIRD MOLARS EXCLUDED)

by C. F. DEATHERAGE JOURNAL OF DENTAL RESEARCH
JUNE 1943

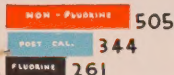
NUMBER OF
SELECTEES
EXAMINED



TEETH WITH
UNTREATED
DENTAL CARIES



FILLED
TEETH



EXTRACTIONS
INDICATED



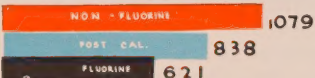
MISSING
TEETH



NO
CARIES
EXPERIENCE



DECAYED
MISSING
and FILLED



INDIVIDUAL CARIES EXPERIENCE AVERAGE



THE ROLE OF FLUORIDES AS AN INHIBITOR OF DENTAL DECAY

ALL CONDITIONS ESSENTIALLY THE SAME EXCEPT FLUORIDE CONTENT OF WATER

ARNOLD and DEAN U. S. PUBLIC HEALTH DEPT. 1938

CITY	NUMBER OF CHILDREN EXAMINED	DENTAL CARIES EXPERIENCE PERMANENT TEETH											NUMBER OF TEETH DECAYED, FILLED and MISSING	FLUORINE CONTENT	
		100	200	300	400	500	600	700	800	900	1000				
GALESBURG, ILL.	273												236 TO	1.5	
COLO. SPRINGS, COL.	404												252		
ELMHURST, ILL.	170														
MAYWOOD, ILL.	171													1.5 TO 1.0	
AURORA, ILL.	633												258 TO		
EAST MOLINE, ILL.	152												323		
JOLIET, ILL.	447													0.9 TO 0.5	
KEWAUNEE, ILL.	123												343 TO		
PUEBLO, COL.	614												444		
ELGIN, ILL.	403													0.5 TO 0.0	
MARION, OHIO	263														
LIMA, OHIO	454														
EVANSTON, ILL.	256												556 TO	0.5 TO 0.0	
WAUKEGAN, ILL.	423												1037		
ELKHART, IND.	278														
MICHIGAN CITY, IND.	236														
NUMBER OF PERMANENT TEETH SHOWING DENTAL CARIES EXPERIENCE, PER 100 CHILDREN EXAMINED															
DENTAL CARIES EXPERIENCE IS COMPUTED BY TOTALING THE NUMBER OF FILLED TEETH (POST DENTAL CARIES) THE NUMBER OF TEETH WITH UNTREATED DENTAL CARIES, THE NUMBER OF TEETH INDICATED FOR EXTRACTION AND THE NUMBER OF TEETH MISSING (PRESUMABLY BECAUSE OF DENTAL CARIES)															

SUMMARY of DENTAL CARIES EXPERIENCE SURVEY

by ARNOLD and DEAN U. S. P. H. 1938

1. The Dental Caries Experience of children living in areas with 1.5 p.p.m. F. content was about 4 times less than those children in the areas that contained NO fluorine.
2. The ratio of dental caries experience increased as the fluorine content of the water went down
3. Nothing as yet has been discovered that so definitely decreased the incidence of dental decay as does fluorine
4. There are no systemic disturbances from the fluorides in concentrations in this survey (1.5 p.p.m.) except for a slight mottling in a few cases.

DR. J. G. FRISCH, MADISON, WISCONSIN
STATE FLUORINE COMMITTEE

reached this fluorine bearing rock. There is no difference in the end result if a fluorine free water is fortified with fluorides by taking them up in solution or if fluorides are added with scientific apparatus. There is, however, with the latter method the additional advantage of intelligently controlled dosage.

This generation should no longer be denied the benefits of fluorine. Here is an element in nature which the body needs while we, by our silence, withhold it. We have set up standards for milk, butter, cheese, meats, and many other food items, and the day is not far distant when it shall be just as illegal for a municipality to sell a deficient water as it is for a grocer to sell substandard milk. Dean suggests the standards for public water supplies be classified into 3 groups:

- (1) Those carrying naturally the optimum concentration of F., i.e. about 1.0 p.p.m. and would therefore require no treatment.
- (2) Those carrying an excessive concentration of F. requiring the removal of the excess in order to protect the community against endemic dental fluorosis (mottled enamel).
- (3) Those deficient in fluoride, to which fluorides should be added to bring its concentration up to the optimum in order to inhibit dental decay.

It has been pointed out by Ast, New York Board of Health, that the optimum concentration may vary slightly in different parts of the country. In hot dry areas where more water is imbibed daily,

it would be necessary to cut down on the concentration so that the individuals in those areas would take in no more fluorides than is considered adequate for dental health, not to exceed 1.6 to 2.0 mg. of fluorine per day, or the equivalent of 3 to 4 pints of a 1 p.p.m. concentration. At this very small dosage, the palatability of the water will not be disturbed in the least and the public can receive daily protection against the ravages of tooth decay without their being aware of it.

CONCLUSIONS

1. The mass control of dental decay by diet alone is impossible and impractical.

2. Any substance worthy of consideration as a factor in the inhibition of dental caries must do so in spite of the high carbohydrate diet in use by the average American.

3. A well balanced diet plus one part per million fluorine in the drinking water supply will drastically cut the incidence of decay.

4. The addition of 1 p.p.m. fluorine to deficient water supplies is in no way harmful and is a safe, feasible, and sensible procedure which will largely solve the pressing public health problem of dental caries.

5. It is the duty of the dental and medical professions to point the way. The subject is both interesting and fascinating and when the public is sufficiently informed and there arises a demand to so fortify deficient municipal water supplies, we will have rendered humanity a great service.

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A Comparative Study of the Influence of Fluorides in Drinking Water on Dental Decay

JOHN G. FRISCH, D.D.S.*

Madison, Wis.

ANIMAL experimentation has been the medium through which man has made many discoveries in the cure, prevention and amelioration of disease. In the relationship between fluorine and dental decay, our fellow human beings—more than 10,000,000 of them in the United States alone, more than 300,000 of them in Wisconsin—are the guinea pigs to which investigators can turn for information and data. Authorities generally agree that flourine free drinking water is associated with a high caries rate and that with a fluorine content of over 1.5 parts per million, there is produced in many individuals unsightly mottled enamel. However, the authorities also agree that one part per million of fluorine is the most favorable quantity to yield the maximum resistance to decay and that will not produce untoward and undesirable results.

Because many progressive communities have become interested in the possibility of controlling the incidence of dental de-

cay by the addition of fluorides to water supplies and because of the special interest in Madison in this regard, the Dane County Dental Society, in cooperation with the Wisconsin State Dental Society, undertook to make a comparative dental caries survey between Madison and Union Grove. Union Grove's water supply contains one part per million of fluorine and its use has been continuous without any relevant changes for the past 45 years. Madison's water is virtually fluorine free.

DESCRIPTION OF UNION GROVE

The village of Union Grove, with a population of about 1000, is located 16 miles west of Racine in southeastern Wisconsin. It is a typical American community, with no one nationality seeming to predominate. Living conditions are above average. Most of its people are engaged in professions and trades that serve the surrounding agricultural area. The water supply is derived from two wells over 600 feet deep. In 1935 an analysis showed that the water contained 1.0 parts per million of fluorine. In 1945, an analysis of three tap water supplies taken 30 days

* Member of the Fluorine Committee of the Wisconsin State Dental Society.

* Chairman of the Fluorine Committee of the Dane County Dental Society.

apart showed that the water contained an average of 1.2 of fluorine parts per million. Twenty-four private wells examined in the area 6 miles north, 6 miles south, and 8 miles east all showed 1.0 fluorine parts per million. Only one mile west of Union Grove, however, the concentration dropped to 0.3 and 12 miles west at Burlington it tested only 0.2

times, its industries employ but a small percentage of its population. The water supply is derived from twelve wells about 750 feet in depth. Its average fluorine content is 0.05 parts per million.

TECHNIQUE

The technique used in this survey was a modification of the Bodecker or unit sys-

SUMMARY OF COMPARATIVE DENTAL SURVEY

Permanent and Deciduous Teeth

UNION GROVE - MADISON

1.0 Fluorine P.P.M.

0.05 Fluorine P.P.M.

6-7-8 AGE GROUP

WISCONSIN STATE DENTAL SOCIETY
and
DANE COUNTY DENTAL SOCIETY
Fluorine Committees

	Number of Children Examined	Cavities Units Filled	Cavities Units Unfilled	Teeth Extracted or Need Extraction	First Molars Units Filled and Carious	First Molars Extracted or Need Extraction	DECIDUOUS TEETH AVERAGE DECAYED UNITS PER CHILD	PERMANENT TEETH AVERAGE DECAYED UNITS PER CHILD
Actual	26	42	41	6	20	0		
UNION GROVE Proportional	130	210	205	30	100	0	3.12	0.77
MADISON Actual	130	546	500	196	298	6	10.28	2.28

GENERAL SUMMARY OF RESULTS

1. Madison children have more than $2\frac{1}{2}$ times as many fillings.
2. Madison children have almost $2\frac{1}{2}$ times as many cavities.
3. Madison children have about $6\frac{1}{2}$ times as many teeth lost by extraction.
4. Madison children have almost 3 times as much decay of the 1st molars.
5. Madison children have more than 3 times as much decay of the baby teeth.
6. Madison children have about 3 times as much decay of the permanent teeth.
7. Union Grove children have only 31% as much decay as Madison children.

fluorine parts per million. With the exception of fluorine content, there is no material difference in Union Grove and Madison water.

DESCRIPTION OF MADISON

The city of Madison has a population of about 67,000. It is the capital of Wisconsin and home of the University of Wisconsin. It has no large foreign born population and no one nationality seems to predominate. Living conditions are above average. Most of its people are not natives of the community but have moved there because it offers opportunities for education, and employment, chiefly in federal and state institutions. In normal

tem of caries evaluation. Each surface of a tooth was charted as to fillings and caries and each surface involved, was counted as one unit—but in no case, even though all of its 5 surfaces were involved, was a single tooth given more than 3 debits. If a surface was both filled and carious, it was counted only once and as filled. Proximal fillings or caries were counted only as one unit unless such fillings or caries involved the occlusal or incisal, in which cases they were counted as two units. Crowned teeth were counted as 3 units. Teeth extracted, or teeth needing extraction, presumably because of caries, were counted as 3 units. In the 6-7-8 age group all missing deciduous premolars were presumed lost be-

cause of caries and counted as 3 units. Congenitally missing, and impacted teeth, or teeth missing, fractured, or restored as the result of accidental injury were not counted.

Inasmuch as the variable under consideration was fluorine content of water, only such children who were native to the Union Grove area and whose history

dentists familiar with the prescribed methods of caries evaluation.

CLINICAL FINDINGS

The actual observation of the very marked reduction in dental decay among the Union Grove children was a refreshing experience to the many Dane County dentists who have practiced their profes-

SUMMARY OF COMPARATIVE DENTAL SURVEY

Permanent teeth only

UNION GROVE - MADISON

1.0 Fluorine P.P.M.

0.05 Fluorine P.P.M.

9-10-11 AGE GROUP

WISCONSIN STATE DENTAL SOCIETY

and

LANE COUNTY DENTAL SOCIETY

Fluorine Committees

	Number of Children Examined	Cavities Filled Units	Cavities Unfilled Units	Upper Anterior's Filled or Unfilled Units	Teeth Extracted or Wood extraction	First Molars Units Decayed	AVERAGE DECAYED UNITS PER CHILD
Actual	24	23	20	0	0	23	
UNION GROVE	120	115	100	0	0	145	1.79
Proportional							
MADISON	120	378	242	33	17	568	5.59
Actual							

GENERAL SUMMARY OF RESULTS

1. Madison children have more than 3 times as many fillings.
2. Madison children have almost $2\frac{1}{2}$ times as many cavities.
3. Madison children have more than 33 times as much decay of the upper anterior's.
4. Madison children have more than 17 times as many teeth lost by extraction.
5. Madison children have almost 4 times as much decay of the 1st molars.
6. Union Grove children have only 32 per cent as much decay as Madison children.

showed a continuous use of a water supply containing one part per million were included in the survey. In the Madison survey, the same restrictions prevailed as to birth in the community and continuous use throughout life of Madison's practically fluorine free water. Exactly 5 times as many Madison children in each age were examined. The examinations were conducted by the Dane County Dental Society and the method was identical in both communities. New mouth mirrors, new S.S. White #5 double end explorers were used in the presence of good light. Both the examiner and the tabulator were

sion in a non-fluorine, rampant decay area. Four age groups were examined and in each group the incidence of dental decay was only 24 to 32 per cent as much as Madison's children in similar age groups. The protection afforded to the deciduous teeth was about the same as imparted to the permanent teeth. There was an overall reduction of 73 per cent in dental decay in the total number of children examined in the two communities.

The decay that was found in the Union Grove children was limited almost entirely to the molar fissures. The examiners charted all fillings as evidence of past

decay; however, many of the pin head fillings in the occlusal surfaces of the Union Grove children were undoubtedly placed there for purposes of protection. This being true, the amount of actual decay is considerably less than was necessary to record. The fissures of the teeth of Union Grove children were less vulnerable to decay because they were, in most cases, more definitely fused; so well fused in fact, that it was impossible to define the line of union. This differential was

with an entire absence of ridges or fossae. In Madison children, 74 instances of caries experience were found in this one fissure alone.

Observations were made of several molar pit fillings that have held without any recurrence of decay for more than ten years. Conventional procedures such as extension of the cavity preparation to include all of the fissure was not always indicated nor was it practical when cavities did form in the occlusal fissures of Union

SUMMARY OF COMPARATIVE DENTAL SURVEY

UNION GROVE - MADISON

1.0 Fluorine P.P.M.

0.05 Fluorine P.P.M.

12-13-14 AGE GROUP

WISCONSIN STATE DENTAL SOCIETY

and

DANE COUNTY DENTAL SOCIETY

FLUORINE COMMITTEES

	Number of Children Examined	Cavities Filled Units	Cavities Unfilled Units	Upper Anterior Filled or Carious Units	Teeth Extracted or Head Extraction	First Molars Units Decayed	AVERAGE DECAYED UNITS PER CHILD
Actual	27	50	50	8	0	71	
UNION GROVE	135	250	250	40	0	355	3.70
Proportional							
MADISON	135	1123	394	176	57	899	12.50
Actual							

GENERAL SUMMARY OF RESULTS

1. Madison children have about $4\frac{1}{2}$ times as many fillings.
2. Madison children have more than $1\frac{1}{2}$ times as many cavities.
3. Madison children have about $4\frac{1}{2}$ times as much decay of the upper anteriors.
4. Madison children have more than 57 times as many teeth lost by extraction.
5. Madison children have more than $2\frac{1}{2}$ times as much decay of the 1st molars.
6. Union Grove children have only 30% as much decay as Madison children.

particularly noticeable on the lingual surface of the upper lateral incisors. The lingual surface of this tooth in the non-fluorine subject is usually made up of a mesial and distal marginal ridge separated by a deep fissure. It is this fissure that ranks very high in susceptibility to decay but in the Union Grove born and reared children examined, not one single instance of such caries experience was found. In the vast majority of Union Grove children, the lingual surface of the upper lateral incisors was smooth and flat

Grove children. In many cases, fusion of the lobes was so complete as to render the tooth as impervious to decay in the future as the tooth would be had the cavity been extended to any other area of the tooth. The physiological intake of fluoride decreases the incidence of decay by preventing the formation or reducing the number of enamel defects.

LACTOBACILLUS COUNTS

The saliva of 20 Union Grove children was collected; of these, 14 were negative

and 6 showed lactobacillus present, the highest of which was 1250 per cubic centimeter. The average dental decay index for the 14 negative children was 1.75 and the average for the 6 positives was 2.00.

In Madison, 32 specimens were taken and the following counts made of lactobacillus per c.c.

- 2 specimens—under 100
- 9 specimens—from 100 to 1000
- 9 specimens—from 1000 to 5000
- 12 specimens—from 5000 to 31,000

in Union Grove, white mottling was present. Eight cases were of the very mild white flaky type and two cases were a little more pronounced white mottling. No brown stained mottling whatsoever was present. From the layman's viewpoint, the mottling was negligible and not esthetically objectionable. The teeth of the Union Grove children generally were more opaque than the teeth of Madison children. There was little or no translucency of the incisors and the shade of the

SUMMARY OF COMPARATIVE DENTAL SURVEY

UNION GROVE - MADISON

1.0 Fluorine P.P.M.

0.05 Fluorine P.P.M.

15-16-17 AGE GROUP

WISCONSIN STATE DENTAL SOCIETY

and

DANE COUNTY DENTAL SOCIETY

Fluorine Committees

	Number of Children Examined	Cavities Filled Units	Cavities Rinfilled Units	Upper Anterior Filled or Carious	Teeth Extracted or Need Extraction	First Molars Units decayed	AVERAGE DECAYED UNITS PER CHILD
UNION GROVE Actual	32	84	54	4	3	90	4.78
UNION GROVE Proportional	160	420	270	20	25	450	
MADISON Actual	160	2113	553	303	171	1190	19.87

GENERAL SUMMARY OF RESULTS

1. Madison children have more than 5 times as many fillings.
2. Madison children have more than 2 times as many cavities.
3. Madison children have more than 15 times as much decay of the upper anteriors.
4. Madison children have almost 7 times as many teeth lost by extraction.
5. Madison children have more than 2 1/2 times as much decay of the 1st molars.
6. Union Grove children have only 24% as much decay as Madison children.

Correlation between dental decay index and lactobacillus counts was established in the majority of cases. In 15 cases where the decay index was from 0 to 10, the lactic counts were below 11,000 in all but one case. In 17 cases where the decay index was from 10 to 39, five had counts of from 11,000 to 31,000, three had counts of 1,000 to 10,000 and three had counts of below 1,000.

INCIDENCE OF MOTTLING

In ten children out of 109 examined

teeth taken from shade guide comparisons were more to the yellows rather than to the blues and grays of non-fluorine teeth.

PRESUMPTIVE EVIDENCE

Many of the 35 dentists, who participated in the survey, also observed that, from superficial appearances, the general health of the Union Grove children was superb. With a reduction of dental decay of 73% below the index of Madison children, it logically follows that the systemic disturbances which have their etiol-

ogy in whole or in part to impairment of the masticating apparatus and the invasion of the body by pathogenic organisms via the apical abscess or directly through the exposed pulp would be proportionately reduced. The incidence of periodontoclasia in later life should also show a substantial reduction because of the elimination of many of its local causative factors; that is, food packs due to loss of contact,

of the chemistry department of the University of Wisconsin submits the following report.

"Yeasts grew abundantly in culture media using Union Grove water. There was no apparent inhibitory effect on the growth of yeasts in media containing 20 parts per million of fluorine, as fluorides, which was as high a concentration in which experiments were made. The

SUMMARY OF COMPLETE DENTAL SURVEY

UNION GROVE - MADISON

1.0 Fluorine P.P.M.

0.05 Fluorine P.P.M.

AGES 6-17 INCLUSIVE

WISCONSIN STATE DENTAL SOCIETY
and
DANE COUNTY DENTAL SOCIETY
Fluorine Committees

	Number of Children Examined	Cavities Filled Units	Cavities Unfilled Units	Upper Anteriors Filled Units	Upper Anteriors Unfilled Units	Teeth Extracted or Need Extraction	First Molars Units Decayed	AVERAGE NUMBER DECAYED UNITS PER CHILD
Actual	109	199	165	12	11	210		
UNION GROVE Proportional	545	995	825	60	55	1050		3.64
MADISON	545	4161	1689	512	441	2955		13.16

GENERAL SUMMARY OF RESULTS

1. Permanent teeth of Madison children began to show loss by extraction at age 7.
2. Permanent teeth of Union Grove children began to show loss by extraction at 15.
3. Madison children have more than 4 times as many fillings.
4. Madison children have more than 2 times as many cavities.
5. Madison children have almost 9 times as much decay of the upper anteriors.
6. Madison children have about 8 times as many teeth lost by extraction.
7. Madison children have about 3 times as much decay of the 1st molars.
8. Madison females had .09% more decay than the males; Union Grove males had .09% more decay than the females.
9. Madison children have more than three times as much irregularity of the teeth of the type that presumably was caused by early loss of deciduous or permanent teeth and loss of space by decay.
10. Union Grove children had an over all dental decay experience of only 27% as much as Madison children.

shifting of teeth to abnormal stresses due to early loss of teeth, and the various types of malocclusions resulting from loss of space by decay and all other local irritants that result directly or indirectly from dental decay.

DOMESTIC AND INDUSTRIAL ASPECTS

No difficulty has been experienced in Union Grove in regard to any inhibitory bacterial or chemical action with the ordinary domestic use of ferments requiring dilution with water. Dr. M. Starr Nichols

fluoride added in these tests was sodium fluoride."

Further investigation was carried on in the Green Bay, Wis. area where the fluorine content of water is 2.5 parts per million. Chemists, bacteriologists, and engineers were interviewed in paper mills, cheese processing plants, pickle factories, bakeries, breweries, and steel mills. No inhibitory enzymatic fermentation action, nor any inhibitory or deleterious bacterial or chemical action was reported with the use of their water.

The chief engineer of one of the largest steel companies reported that when they used a soluble oil in suspension in water as a coolant in high speed machines of all kinds that no corrosive action was noticeable. In their heat treatment of metals, which is a physical action, and in which water is used, they report that with all types of steels, carbon, alloy, and the stainless varieties that they get as uniform a result as anywhere in the country.

The consensus of opinion was that if any industry thought that it was being penalized either because of the inferiority of its product or a possible harmful effect upon its machinery due to the fluorides in the Green Bay water, that they could remove those fluorides or change their water supply to nearby fluorine-free Lake Michigan. No such action has ever been taken nor is it contemplated by any industry in the Green Bay area.

CONCLUSIONS

This comparative survey is but one of at least 27 others reported in regard to the caries experience of fluoride and non-fluoride areas. Well over 15,000 children were studied in these surveys. In every case it has been found that where 1.0 fluorine parts per million or more has been present in the drinking water there

is a substantial reduction in dental caries. Fluorine ingested during the first eight to ten years of life imparts a protection; and according to the reports of McKay, Deatherage and others, there is definite proof that the beneficial influence of fluorine as exerted against the decay process, having once been conferred, remains permanent and is not subject to serious diminution in later life.

Thus far no method of mass control of dental decay has been so well supported by facts and evidence as has been the fluorinization of domestic water supplies. Should this practice become universal in areas of fluorine deficiency, and the general public more educated in matters of diet, hygiene, and proper dental care, there is a great probability that the pulpless tooth and the alveolar abscess would become almost non-existent and the loss of teeth due to decay, negligible.

The evidence is in Union Grove and hundreds of other communities where fluorides are present as to the effects of fluorine on dental decay and the general health of the people. We need not deny the coming generation the benefits of fluorine while awaiting the results of "controlled experiments" for further confirmation of presently known scientific facts.

Significance of Dental Caries in Malocclusion

WADE R. PLATER, Orthodontist

Madison, Wis.

TOOTH decay is perhaps the most widely discussed health problem of this generation, but in the efforts to combat this disease very little has been accomplished. Much has been said and published about restricted diet inhibiting decay. Our only progress in that approach has been made with segregated groups of children where they must eat the foods given them. This procedure has yielded some excellent experimental data and proves what can be done when there is absolute control. However, it has accomplished very little with the masses of uncontrolled children. It seems a more practical method of reaching the mass of our young people should be discovered.

Much evidence has been found to support the fluorine impregnation method for drinking water. Where there is a natural fluorine content of 1 part per million by volume, there is a decided drop in the incidence of decay in the teeth of the children of that area. Where there is a drop in caries, there is also a decided drop in the incidence of malposition of teeth.

The most pernicious of the etiological factors which promote the abnormalities of occlusion is the early loss of both deciduous and permanent teeth. When a tooth is prematurely lost there is a tendency for those teeth back of the lost member to move forward. The result of this forward drifting produces a loss of normal cusp relationship between the opposing arches. This drifting also occurs, to a lesser degree, when the contacts are lost by caries.

Factors which disturb the continuity of the dental arch, such as the loss of contacts or loss of a tooth, eliminate a growth stimuli that is needed to produce

perfect balance in tooth and arch relationship.

One of the greatest forces influencing the growth of the face is the forward drive created when the teeth come into function. The angle of the upper teeth is slightly forward and downward—the angle of the lower is forward and upward. This is more particularly true in the molars; thus when the posterior teeth come into function, there is a resultant forward drive. This forward drive is an important factor in stimulating the forward growth of the dental arches.

One other mechanism comes into play here, and that is the restraining force of the facial musculature. Primarily the orbicularis oris, buccinator, and associated muscles make up this restraining force.

It should be pointed out that the critical period in a child's development comes during the time between the eruption of the 1st molars and the 3rd molars. During that period it is imperative that the integrity of the dental arch be maintained lest we have mutilated arches with subsequent occlusal anomalies. This condition may come about by the premature loss of tooth material in any manner. Just as soon as a portion of the tooth, such as the early decay of the proximating surfaces occur, the two mentioned forces produce a squeeze. The result will be a shortening of the dental arch length.

In 1933 Willitt surveyed 1,000 cases of malocclusion. He stated, "that 8.4% of the malocclusions could be attributed to the premature loss of deciduous teeth in whole or in part." This study included children up to 10 years of age. That percentage is great enough, and if studies were carried to higher age levels it might run even higher, because when normal

growth factors become perverted their influence might be felt up to the complete eruption of the second molars. Shortening of the length of the dental arch or arches obviously will throw the occlusion out of balance and impair normal function.

Since the primary object of this article is to show the influence of decay upon occlusal anomalies, further discussion will be limited to a recent survey made for the purpose of determining the effect of caries upon occlusal irregularities.

In the surveys made by the fluorine committees of the Wisconsin State Dental Society in conjunction with the Dane County Dental Society, some startling figures were obtained.

The following two areas having drinking water of known fluorine content were selected:

Union Grove, Wisconsin, fluorine content of 1 part per million of water by volume, and

Madison, Wisconsin, fluorine content of 1/20 of 1 part per million of water.

Children between the ages of 12 and 17 years, inclusive, were examined for purposes of orthodontic comparisons. It was found that Madison children have 4 times as many fillings as Union Grove children, 2 times as many cavities, 3 times as much decay in the 1st molars, and 8 times as many teeth lost by extraction. Among the Madison children the loss of permanent teeth by extraction began at the age of 7. Among the Union Grove children this loss began at the age of 15.

Madison children examined for malocclusion were greater in number. There were 320 in Madison and 49 in Union Grove, so it is necessary to report percentages as were found. Four groups were set up as follows:

Group N—Includes those that approach the ideal or the correct mesio-distal relationship of all teeth.

Union Grove 40%

Madison 12%
or more than 3 to 1 in favor
of Union Grove

The other groups include those classed as malocclusions.

Group 1

Molars were in correct mesio-distal relationship, to each other while those teeth anterior to the molars were irregular.

Union Grove 30%
Madison 50%

Group 2—Distal occlusion

All lower teeth were distal to normal to the uppers.

Union Grove 30%
Madison 36%

Group 3—Mesial occlusion

All lower teeth were mesial to normal to the uppers.

Union Grove None
Madison 2%

Madison ranks higher in malocclusions while Union Grove shows a higher percentage of the normal.

CONCLUSIONS

The salient points of comparison may be summarized.

There was 40% normal mesio-distal relationship in Union Grove against 12% in Madison—over 3 to 1, which seems to indicate clearly that the lack of disturbance by decay has allowed the teeth to erupt into more nearly normal mesio-distal relation.

Compare these figures with caries incidence in the same groups. Madison children have 3 times as many cavities and 3 times the number of malocclusions as Union Grove children; furthermore, the irregularities present among the Union Grove children seemed to be less extreme. Many were unilateral; however, they were classed as malocclusions.

It is evident that decay plays a major role in the etiology of malocclusion. These

figures support the contention that there is less malocclusion in Union Grove because there is less loss of tooth structure by decay.

Since all other conditions were essentially the same in Madison and Union

Grove, and since many other surveys indicate that the fluoride content of water is the inhibitor of dental decay, it can be presumed that here too fluorine is the inhibiting factor of malocclusion by inhibiting dental caries.

APPENDIX "E"

NATIONAL RESEARCH COUNCIL OF CANADA

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

1. Formation of the Associate Committee on Dental Research

The Canadian Dental Association having taken cognizance of the need for organization of dental research on a national basis, petitioned the National Research Council in September, 1944, requesting that the Council establish an Associate Committee for Dental Research and provide funds to support the work of the proposed Committee. After due consideration, the National Research Council established the Associate Committee for Dental Research, in March, 1945. Several meetings of the Committee have been held since its establishment and the work of the Committee is proceeding favourably.

2. Objectives of the Committee

- (i) The stimulation of research of interest to dental science among members of the dental profession, and also in the basic and medical sciences.
- (ii) To coordinate dental research in Canada.
- (iii) To encourage close collaboration with other research organizations in problems of mutual interest.
- (iv) To advance the application of research results in the interests of improved national dental health.

3. Functions of the Committee

In pursuit of these objectives the Committee will make grants in aid of approved projects of dental interest. Grants are made only for the actual expenses of investigation. They are not intended to support the grantee in carrying out the research, but may be used in whole or in part for the payment of assistants, for the purchase of supplies and special apparatus, for necessary travelling, secretarial, or publishing expenses etc. The applications must be made by responsible persons who are competent to conduct the investigations and who have access to the laboratory or clinical facilities required for the research.

4. Projects Supported by the Committee

The following projects are at present receiving support from the Committee and are listed here as examples of the types of research considered relevant.

- (1) An investigation of the chemical mechanisms involved in the decrease of dental caries by fluorides.

- (ii) Chemical studies of nitrous oxide for dental anaesthesia.
- (iii) An investigation of packing materials in the treatment of periodontal disease.
- (iv) Improvement of certain properties of the acrylic resin denture base.
- (v) A study of the effects of altitude, acceleration and deceleration on oral tissues.
- (vi) An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

5. Encouragement of Applications

The Committee feels that progress in dental research would be accelerated by more general awareness, in the basic science and medical science departments of the nature of the present problems of dentistry.

Any such department which is interested in a dental research project is encouraged to make application for assistance from the Dental Committee.

The Committee would also be glad to receive and advise on informal inquiries from departments uncertain whether their problems and interests are or are not relevant to dental research.

6. Procedure in making an Application

Application for a "Grant in Aid" for the support of a project related to research in dentistry must be made on the regular forms obtainable from the Secretary of the Associate Committee on Dental Research, Mr. S. J. Cook, National Research Council, Ottawa, Canada.

In general, applications should be submitted by 1 February in each year so that the budget of the Committee can be set up to take care of the projects which are accepted. Consideration of applications received at other times may have to be deferred.

7. Personnel of Associate Committee on Dental Research

Representing Dental Profession

Term to
expire

Dr. R. G. Ellis	Chairman of the Committee. Professor of Operative Dentistry Director of the Dental Clinic University of Toronto; Chairman of the Research Committee, Canadian Dental Association.	31 March 1948
Dr. H. K. Box	Research Professor of Periodon- tology, University of Toronto.	31 March 1949
Dr. G. D. Stibbs	Member of the Board of the British Columbia Dental Association.	31 March 1949
Dr. H. R. MacLean	Associate Professor of Operative Dentistry, Faculty of Dentistry, University of Alberta.	31 March 1947
Dr. M. H. Garvin	Editor in Chief of the Journal of the Canadian Dental Association	31 March 1947
Dr. E. Charron	Dean of the Faculty of Dental Surgery, University of Montreal.	31 March 1948

Representing the Canadian Dental Corps (ex officio)

(Brig. F. M. Lott	formerly Director General of Dental Services, Canadian Dental Corps, now retired)
Col. D. S. Coons	Director General of Dental Services, Canadian Dental Corps.
(Lt.Col. G. Franklin	formerly Canadian Dental Corps, now retired).
Major W. J. Linghorne	Canadian Dental Corps.

Representing Basic and Medical Sciences

Dr. E. F. Burton	Professor of Physics and Head of the Department, Director of the McLennan Laboratory, University of Toronto	31 March 1949
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Representing Basic and Medical Sciences (cont'd)

Term to
expire

Dr. J. B. Collip	Research Professor of Endocrinology Director of the Research Institute of Endocrinology, McGill University.	31 March 1949
Dr. A. R. Gordon	Professor of Chemistry and Head of the Department, University of Toronto.	31 March 1947
Dr. C. H. Best	Professor and Head of the Department of Physiology, Director and Professor in the Banting and Best Department of Medical Research, University of Toronto.	31 March 1947
Dr. D. L. Thomson	Dean of the Faculty of Graduate Studies and Research Professor of Biochemistry, Chairman of the Department, McGill University	31 March 1947
Dr. J.K.W. Ferguson	Professor of Pharmacy and Pharmacology, University of Toronto.	31 March 1948
Dr. D. Mainland	Professor of Anatomy, Dalhousie University	31 March 1948
Dr. O. W. Ellis	Department of Metallurgy, Ontario Research Foundation.	31 March 1948
Dr. C. J. Mackenzie (ex officio)	President, National Research Council.	
Mr. S. J. Cook	Secretary of the Committee, National Research Council, O T T A W A.	

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
FOURTH MEETING
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

22 OCTOBER, 1946

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- O - An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry, by O. J. Walker and H. R. MacLean

Initial Distribution

Proceedings of the Fourth Meeting

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

3. Minutes of Previous Meeting Held in the Council Chamber

THE CHAIRMAN said the National Research Building
of the Committee and of the first meeting of the Executive
had been distributed 9:30 a.m., 22 Oct. 1946.

It was moved by Dr. Burton and seconded by
Dr. Mainland:

1. Attendance

Dr. R. G. Ellis, Chairman
President C. J. Mackenzie (ex-officio)
Dr. Harold K. Box
Dr. E. F. Burton
Dr. D. S. Coons
Dr. M. H. Garvin
Dr. J. W. Linghorne
Dr. H. R. MacLean
Dr. D. Mainland

Mr. S. J. Cook, Secretary

By invitation

Mr. D. R. Christie
Dr. L. V. Janes
Dr. G. H. W. Lucas
Col. E. M. Wansbrough
Dr. A. E. R. Westman

Apologies for their absence were received from
Dr. C.H. Best, Dr. E. Charron, Dr. J.B. Collip, Dr. O.W. Ellis,
Dr. G. D. Stibbs and Dr. D. L. Thomson.

2. Chairman's Remarks

THE CHAIRMAN welcomed the guests at the Meeting. He noted especially that Dr. Janes had been recently appointed Chief of the Division of Dental Health of the Department of National Health and Welfare. Dr. A. E. R. Westman and Mr. Christie had been invited to discuss project DR 5 which is being carried on in cooperation with the Ontario Research Foundation. He also welcomed Col. Wansbrough newly appointed Director-General of the Dental Corps and Dr. Lucas who attended the Meeting in

place of Dr. Ferguson, to report on Project DR 2. He also expressed gratification at the attendance of the President of the National Research Council.

3. Minutes of Previous Meetings

THE CHAIRMAN said that the proceedings of the Third Meeting of the Committee and of the First Meeting of the Executive had been distributed to the Members.

It was MOVED by Dr. Burton and SECONDED by Dr. Mainland:

That the proceedings of the Third Meeting of the Committee and of the First Meeting of the Executive, having been circulated, be taken as read and APPROVED.

CARRIED.

4. Business arising out of the Minutes

(i) Reprints - 3rd Mtg. Min.11 - DR. MAINLAND asked whether it was the intention to secure reprints of all papers on Dental Research written by members of the Committee or whether it was intended only to secure reprints of papers on subjects of research sponsored by the Committee.

THE CHAIRMAN said he thought it would be of interest to members of the Committee to receive reprints of any papers written by members of the Committee, and that the motion should not be regarded as restricting the purchase of reprints to papers dealing with subjects sponsored by the Committee.

(ii) Membership - 3rd Mtg.Min.4 - THE CHAIRMAN stated that Col. Coons had now retired from the Dental Corps and that Col. Wansbrough would therefore automatically succeed Col.Coons as a member of the Committee.

(iii) Grants - 3rd Mtg.Min.8 - DR. BURTON inquired whether the grants recommended by the Committee at the Third Meeting had been approved by the National Research Council.

THE CHAIRMAN replied that all grants, except the encumbrance of \$6,000 under DR 8 had been approved. He had reported on the programme of work on fluorine (as requested in minute 8) and his remarks would be found in minute 7 of the First Meeting of the Executive.

(iv) Pamphlet - 3rd Mtg. Min.6 - THE CHAIRMAN reported that a descriptive pamphlet had been prepared regarding the activities of the Committee. Copies were distributed to the members. The Chairman said that a tentative mailing list for the descriptive pamphlet had been compiled, 1st Exec. Mtg. Min. 9. The question of additions to this distribution list would be raised later in the present meeting (see Min. 6) He said that no distribution had yet been made of this pamphlet.

5. Reports on Projects

(i) DR - 1 Dr. James J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

An interim report for the period 15 February, 1946 - 15 July 1946 by Dr. Rae and Mr. C. T. Clegg on this subject was presented and the discussion part of the report was read by the Chairman.

The report appears in full as APPENDIX A.

(ii) DR - 2 Dr. Geo. H. W. Lucas

"Chemical study of nitrous oxide for dental anaesthesia"

DR. LUCAS presented a report by Dr. R. J. S. Tickle on one phase of this work dealing with the water content of anaesthetic nitrous oxide. The report appears in full as APPENDIX B.

Discussion

DR. BURTON expressed the opinion that the subject dealt with in this report was of considerable importance and that on completion of the work, the report should be sent to the Canadian Committee on Pharmaceutical Standards for their information and any action that may seem to them to be desirable.

THE CHAIRMAN pointed out Dr. Ferguson had recommended that the work be published (3rd Mtg. Min.5) and that when the manuscript had been completed, it should be submitted to the Executive for consideration in their capacity as the Committee on Publications, after which it might be published in the Canadian Journal of Research or some other suitable Journal.

AGREED.

*
see
Lucas
Tickle

DR. LUCAS then presented a second report under DR 2 under the title "A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines."

The report appears in full in APPENDIX C.

Discussion

DR. BURTON said he thought it was very important that inspection of gas delivery apparatus used for anaesthesia should be made by government authorities.

THE CHAIRMAN agreed that when the work was completed, a strong recommendation should be made.

DR. JANES suggested that the Dominion Council of Health, which is a very representative body, might be a suitable organization to take action on the Committee's recommendations.

*Dr. B.D. Cameron,
Deputy Minister,
Health
(Chairman)*

THE PRESIDENT thought that an effort should be made to ascertain definitely what organization would have authority to deal with recommendations made by the Committee. He pointed out that while machines may be accurate when first produced, they may not continue to deliver gas at the rates indicated on their dials after they have been in use for some time. Inspection under operating conditions was therefore important.

**
write*

DR. COONS suggested that the subject might be brought to the attention of the Canadian Dental Association.

DR. WESTMAN inquired whether any simple method was available or could be devised for the use of dentists in checking machines while in use in their offices.

DR. LUCAS said in reply that it was quite possible to determine oxygen loss rapidly and he believed it would be feasible to develop a test of the kind referred to by Dr. Westman. He said he would carry out some experimental work on this subject.

write Lucas see Table

DR. GARVIN reminded the Committee that the present tendency was towards the use of expert anaesthetists in dental work, although all dentists were trained in the giving of anaesthetics.

(111) DR 3 - Dr. H. K. Box

"Effects of Penicillin in Deep Pockets"

DR. BOX stated that he had nothing further to report on this subject except that work was proceeding satisfactorily. He

mentioned that fusiform organisms with flagella had been reported from Sweden, and that in carious dentine some fibrous material has been found. He said he would have a report of the project ready for presentation at the next meeting of the Committee.

(iv) DR 4 - Dr. H. K. Box

"Investigation of packing material in the treatment of periodontal disease"

DR. BOX presented an interim report on this subject which appears in full in APPENDIX D.

Discussion

DR. LUCAS said that reference had been made in the report by Dr. Box to bacteriostatic drugs and also to bacteriocidal drugs. It was his view that bacteriostatic drugs could be used locally, but that bacteriocidal drugs would be likely to attack tissues.

DR. BOX said that the use of eugenol on cotton had not produced any attack on tissues that he had observed during five years' work, but he thought that histological sections might be worth making as a check on the results observed.

THE CHAIRMAN thought this was a good suggestion and asked Dr. Box to make the necessary arrangements to which he agreed.

DR. LINGHORNE said that all experimental work to date had been done with staphylococcus, but that the experiments would be repeated with streptococcus. It was desired to evaluate the mechanical and therapeutic effects on tissue.

(v) DR 5 - Major R. L. Twible

"Acrylic resin denture base"

DR. WESTMAN reported on this subject and presented a summary of work to date which had been prepared by Mr. D. R. Christie, Research Fellow. This report No. CR 4602 together with graphs distributed at the Meeting appears in full in APPENDIX E.

Other reports submitted during the progress of the work by Dr. Twible were also laid on the table and it was agreed that these, because of the extra detail contained in them, should also be included as appendices to these proceedings.

(vii) DR 6 - Dr. D. S. Coons

"Effects of altitude change on oral tissues"

DR. COONS presented a mid-year report on this subject which is being investigated by the Canadian Dental Corps. His report appears in APPENDIX L.

COL. WANSBROUGH stated that the Canadian Dental Corps would carry this project forward according to the plan presented to the Committee by Col. Coons.

(viii) DR 7 - Dr. J. S. Bagnall

"Critical survey of the literature on dental caries"

DR. BAGNALL's report which was presented by Dr. Mainland appears in full in APPENDIX M.

Discussion

DR. BURTON said he supposed that the report being prepared by Dr. Bagnall would be arranged in accordance with standard practice, and he hoped that it might be possible to publish the bibliography in printed form for general distribution.

THE CHAIRMAN said that he hoped to have Dr. Bagnall present his final report at the next meeting of the Committee, when an opportunity would be afforded the members to see the form in which the material has been assembled and to offer comments on it before the report is printed. He agreed that it was desirable to have the bibliography prepared in such a way that it could be readily distributed. ** write
will be
ready
to report -
if as - invite
to meeting..*

(ix) DR 8 - Dean A.D.A. Mason

"A study of the D.M.F. caries rate of the children of Brantford prior to the addition of fluorine to the water supply"

THE CHAIRMAN said that in the concluding months of the fiscal year 1945-46, he had been authorized to spend up to one thousand dollars on the organization and conduct of a survey to determine the D.M.F. caries rate of Brantford children prior to the addition of fluorine to the drinking water supply in that city. He had accordingly arranged with Dean Mason and Dr. Hunter to carry on the work and studies had been made of five hundred children including one hundred in each of the ages 5, 7, 9, 11 and 13. He pointed out that a similar investigation had been

made previously in Timmins, Ontario, and the age group selections in Brantford had been arranged so that the surveys in the two centres could be coordinated.

The report on Brantford fluorine survey, as conducted by Dr. H. A. Hunter appears in full in APPENDIX N.

Discussion

This subject was considered at the First Meeting of the Executive and discussion on it appears in Minutes 6 and 7 of those proceedings.

THE CHAIRMAN said that the proposed programme of work on fluorine, for which six thousand dollars had been encumbered for 1946-47 (3rd Mtg. Min.8) had been discussed by the National Research Council. The opinion had been expressed that Associate Committees of the National Research Council should not engage in surveys as it was felt that this field of work was more properly a function of departments of government, either provincial or federal, who were concerned with matters pertaining to health. The subject had therefore been discussed with Dr. James, Chief of the Division of Dental Health of the Department of National Health and Welfare, and with Dr.G.D.W.Cameron, Deputy-Minister of that Department. It had been agreed that the Associate Committee on Dental Research might act in an advisory capacity to the Department of National Health and Welfare in regard to any proposed dental surveys.

DR. JAMES said that his Department had considered the subject carefully, and that they were prepared to take on the financial responsibility for dental surveys of the kind mentioned by the Chairman, but that as yet there had been some difficulty in finding a suitable observer. He thought it would be important to include in such surveys about 100 adults in each area as well as the children, since it was generally assumed that a moderate amount of fluorine in the drinking water supply was beneficial up to about age 14, but that little information was available as to its effect on older persons. He thought his Department would need direction from the Associate Committee on Dental Research in respect of dental surveys and he was glad to hear the Chairman say that the Committee would be willing to cooperate fully with the Department in such investigations.

DR. GARVIN emphasized the importance of including older age groups in the survey, and mentioned that Gottlieb had reported that fluorine is responsible for the loss of teeth ten years earlier than when fluorine has been absent from the water supply.

It was MOVED by Dr. Burton and SECONDED by Dr. Box:

That in the opinion of the Associate Committee on Dental Research surveys should be carried out in selected areas to determine the effects of fluorine in the drinking water supplies, and that the Executive be authorized to cooperate with the Division of Dental Health of the Department of National Health and Welfare in working out a satisfactory programme of investigation on this subject.

*Exact.
write first*

CARRIED.

DR. MAINLAND expressed the hope that all members of the Committee would read carefully Appendix "D" which had been issued as a Supplement to the Proceedings of the First Meeting of the Executive and which contained a great deal of valuable information on the subject of water-borne fluorides and dental health. He thought that a careful study of this report would be essential in the planning of future studies so that the Canadian records obtained on this subject may be as complete as possible.

DR. WESTMAN said that in the planning of surveys it was necessary to give consideration to the statistical significance of the numbers of persons examined. He said that he was a member of the Associate Committee on Mathematical Statistical Methods recently established by the National Research Council, and that one of the functions of this new Committee was to give advice regarding methods to be followed in the conduct of investigations under the auspices of the National Research Council. He suggested that advantage be taken of the establishment of this Committee to secure advice from the statistical point of view in the planning of the proposed surveys.

THE CHAIRMAN invited all members of the Committee to give careful consideration to this subject, and to submit their recommendations to the Secretary.

(x) DR 9 - Dr. O.J. Walker and Dr. H.R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

DR. MACLEAN presented a report on this subject which appears in full in APPENDIX "C".

6. Descriptive Pamphlet (1st Exec. Min.8)

THE CHAIRMAN laid on the table copies of a pamphlet regarding the Associate Committee on Dental Research which had been prepared by the Secretary according to copy approved at the First Meeting of the Executive. He drew attention to the proposed distribution list (1st Exec. Min.9) and asked for suggestions.

DR. BURTON thought the distribution of this pamphlet would be helpful to the Committee, and he suggested that it should be accompanied by a covering note signed by the Chairman of the Committee. He assumed that the pamphlet had been approved by the President of the National Research Council.

DR. MAINLAND suggested the following additions to the distribution list: University departments of Hygiene, Public Health, and Food Chemistry; University hospitals; Journal of Orthodontics and Oral Surgery.

7. Publicity in the Promotion of Dental Research

DR. BURTON suggested that, in addition to the pamphlet outlining the scope and function of the Committee, it would be helpful if a news article on Dental Research were prepared and published. He thought that progress in dental research depended in large measure on getting groups of students to stay for several years in the universities preparatory to undertaking fundamental dental research. He did not believe it was possible to combine practice and research. In the Department of Physics, at the University of Toronto, he said he had now about seventy students teaching up to a maximum of twelve hours a week, and devoting the rest of their time to research studies leading to the Ph.D. degree. It was often said that there was no use training graduate students unless it was known that there would be jobs for them on completion of their research studies, but in the field of meteorology, a special course had been designed to provide men with suitable training for work in the Meteorological Service of Canada, and although it had been thought that one or two years would be sufficient to provide all the men required, there were now about ninety persons employed in this work, and there was still need for more. He suggested that men trained in dental research would similarly find places opening up for them when they were ready to leave the university. *

DR. GARVIN felt that a large proportion of the dental profession are not aware of the possibilities of dental research, and that it was very desirable that information should be given to the profession on this subject. He offered to give any required

amount of space in the Journal of the Canadian Dental Association to this subject.

THE CHAIRMAN suggested, and it was agreed, that an editorial on the Committee's work should be prepared by Dr. Garvin with the cooperation of the Chairman, and that when such an editorial had been approved by the National Research Council, it should be published and reprinted for general distribution to students and members of the profession *

8. Grants-in-Aid

(i) DR 4 - Dr. H. K. Box

"An investigation of packing material
in the treatment of periodontal disease"

THE CHAIRMAN stated that one thousand dollars had been encumbered (3rd Mtg. Min. 7 iv) for the employment of a bacteriologist to work on the investigation of packing materials in the treatment of periodontal disease, pending an application for this additional grant. An application had since been received from Dr. C. H. Best and Dr. H. K. Box, and he recommended that this application be confirmed.

APPROVED - \$1,000.

(ii) DR 10 - Dr. G. M. Macdonald

"Facial Prostheses"

THE CHAIRMAN said that this application had been considered by the Executive (1st Exec. Min. 4) and recommended for approval but that, as a quorum had not been present at the meeting, it had been decided to hold the application over for presentation at this meeting. He recommended that the grant be confirmed as recommended by the Executive.

APPROVED - \$800.

(iii) DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological
study of the role of the condyle in mastication"

THE CHAIRMAN discussed this application briefly pointing out that the proposed assistant had been coming from Hamilton to the Dental College at Toronto for two half-days each week during the last two years at his own expense to carry on research on the subject for which this grant is requested. He thought it would be useful to give encouragement in this investigation, but that in view of the fact that one-half of the year has now gone by, he would recommend that the initial grant be made for six months

only to 31 March 1947, and that the amount of the grant be one-half that asked for by the grantee for the full year.

APPROVED - \$1425.

9. Tropicalization of dental supplies and equipment

DR. BURTON informed the Committee that Dr. D. S. Coons had done considerable work on the tropicalization of dental supplies and equipment with special reference to the use of such equipment in India. He understood that a report had been prepared for the Canadian Dental Corps by Dr. Coons and he suggested that the Committee make enquiry as to whether this report could be released for publication as an Addendum to the proceedings of the Committee in order that the information in it might be made available to the members.

COL. WANSBROUGH said that the report was the property of the Department of National Defence, and that he did not know whether it could be released for distribution to members of the Associate Committee on Dental Research, but he would make enquiries in this connection and report back at the next meeting of the Committee. *

10. Membership of the Committee

It was MOVED by Dr. Burton and SECONDED by Dr. Linghorne:

That Dr. L. V. Janes, Chief of the Division of Dental Health, Department of National Health and Welfare, be recommended to the National Research Council for membership in the Associate Committee on Dental Research.

CARRIED.

Dr. Box:

It was MOVED by Dr. Burton and SECONDED by

That Dr. D. S. Coons, former Director-General of Dental Services, Canadian Dental Corps, be recommended to the National Research Council for membership in the Associate Committee on Dental Research.

CARRIED.

11. Resolution of Sympathy

That this Committee extends its deep sorrow and understanding sympathy to Mr. S. J. Cook, Secretary of the Committee, in his recent sad bereavement in the passing of Mrs. Cook.

The Meeting adjourned at 3:20 p.m.

APPENDIX "A"

Interim Report No. 2 on DR-1

THE CHEMICAL MECHANISMS OF FLUORINE ACTION ON DENTAL CARIES

Period Covered - Feb. 15, 1946 - July 15, 1946.

Research Workers - James J. Rae, Ph.D.
Charles T. Clegg, Phm.B.

Institution - Department of Chemistry,
University of Toronto.

(a) Fluorine and Salivary Phosphatase

The optimum pH of salivary phosphatase was found to be 5.05 with 0.005 M sodium phenyl phosphate as a substrate and sodium veronal as a buffer. The addition of sodium fluoride inhibits the activity of salivary phosphatase, as shown in the following table:

TABLE I

INHIBITORY EFFECT OF SODIUM FLUORIDE ON
SALIVARY PHOSPHATASE

Fluorine p.p.m.	Phenol liberated mg. per 1 ml. of saliva*
100	.022
50	.023
10	.027
1	0.139
0	0.164

* Conditions of experiment:- pH 5.0;

concentration of substrate - 0.005 M sodium phenyl phosphate;
incubation period - 1 hour at 37°.

Although sodium phenyl phosphate is not a natural substrate for salivary phosphatase, the substitution of sodium glycerophosphate as a substrate is not practical with crude salivas because of the large amounts of inorganic phosphate already present. Attempts to remove the inorganic phosphate present by adding magnesia mixture inactivated the phosphatase.

(b) Calcium Phosphate Experiments

One of the chemical factors involved in dental caries is the fluorine content of the water used, and it was suggested in our last report (Oct. 1st, 1945 - Feb. 15th, 1946) that this may be due to the deposition of calcium fluoride which replaces the tooth enamel dissolved by lactic acid. The addition of anions which form insoluble calcium salts (e.g. oxalate) and cations which form insoluble phosphates (e.g. lead or silver) exhibit an effect analogous to fluoride, i.e. protect teeth from acid decalcification and reduce the apparent solubility of tooth enamel and tri-calcium phosphate in 1% lactic acid. Other factors must be operative in dental caries since wide differences in immunity to caries are found in the same locality and numerous attempts have been made to find some chemical difference between the salivas of caries-free and caries-active persons.

Karshan(1), (2) has stated that although the mg.% calcium and mg.% phosphorus are the same in salivas from both caries-free and caries-active individuals, the change in the concentrations of these ions produced by shaking the salivas with excess powdered tri-calcium phosphate is remarkably different. In stimulated salivas from caries-free individuals the % calcium removed on shaking with tri-calcium phosphate was 65% whereas only 39% was removed in the salivas of the caries-active group. For unstimulated salivas the values for calcium removal were 54% in the caries-free and 20% in caries-active salivas.

The changes in phosphate values were also marked. The stimulated saliva values were in the caries-free case 20% removed and in the caries-active 45% removed whereas with unstimulated salivas the removal was almost the same:-63% in caries-free and 67% in caries-active salivas.

These surprising results prompted us to investigate this phenomenon further in an attempt to gain some insight into the chemical processes involved. On shaking salivas from a miscellaneous group of subjects with tri-calcium phosphate (Kahlbaum Reagent) we were unable to observe any decrease in phosphate

"A-3"

as observed by Karshan, but did obtain varying decreases in the calcium concentration. A summary of these results is presented in Table II.

TABLE II

THE CHANGE IN CALCIUM AND PHOSPHORUS CONCENTRATION OF SALIVA ON SHAKING WITH TRI-CALCIUM PHOSPHATE

Before shaking		After shaking		Change produced	
Calcium mg. %	Phosphorus mg. %	Calcium mg. %	Phosphorus mg. %	Calcium mg. %	Phosphorus mg. %
-	15.0	-	31.7	-	+16.7
-	12.7	-	33.8	-	+21.1
20.9	-	7.15	-	-12.75	-
23.6	12.6	5.78	28.0	-17.82	+15.4
9.75	13.0	2.89	31.4	- 6.86	+18.4

Aqueous solutions of calcium chloride with varying concentrations of calcium in buffered media (Veronal buffer) were then shaken with tri-calcium phosphate and the concentration of calcium and phosphorus rose in all but two cases where it remained practically unchanged. The solubility of the tri-calcium phosphate decreased slightly with increasing calcium concentration as shown by the phosphorus content of the supernatants. Sodium phosphate solutions had an analogous effect, but solutions containing both calcium chloride and sodium phosphate or calcium nitrate and sodium phosphate exhibited marked decreases in calcium content, as shown in Table III, although the phosphorus concentration rose in all cases.

TABLE III
THE EFFECT OF SHAKING SOLUTIONS CONTAINING CALCIUM
AND PHOSPHATE IONS WITH TRI-CALCIUM PHOSPHATE

Solution	Before shaking		After shaking		Change produced	
	Ca mg. %	P mg. %	Ca mg. %	P mg. %	Ca mg. %	P mg. %
Buffer	0	0	6.6	13.5	+6.6	+13.5
CaCl ₂	3.3	0	6.5	12.5	+3.3	+12.5
CaCl ₂	5.5	0	7.9	12.0	+2.4	+12.0
CaCl ₂	10.2	0	12.0	12.2	+1.8	+12.2
Na ₃ PO ₄	0	13.4	1.22	22.9	+1.22	+ 9.5
CaCl ₂ Na ₃ PO ₄	5.3	13.3	1.0	19.8	-4.3	+ 6.5
Ca(NO ₃) ₂ .Na ₃ PO ₄	8.4	12.6	2.6	18.2	-5.8	+ 5.6
Ca(NO ₃) ₂ .Na ₃ PO ₄	14.0	6.9	4.86	10.8	-9.14	+ 3.9

DISCUSSION

If some insoluble calcium salt is formed with a ratio by weight of Ca/P greater than the ratio produced by dissolving calcium phosphate in water (0.49), then the formation of such an insoluble salt would explain the above results. The precipitation of either pure tri-basic calcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$ Ca/P = 1.93 or dibasic calcium phosphate (CaHPO_4) Ca/P = 1.29, would lead to a decrease in calcium concentration and an increase in phosphate concentration.

Since saliva is a suspension of proteins and not a solution of inorganic calcium salts and phosphates, perhaps when calcium is analysed by utilising a tri-chloroacetic acid filtrate the calcium proteinates may be hydrolyzed by the tri-chloroacetic acid, whereas on shaking the salivas with calcium phosphate the calcium proteinates may be precipitated or adsorbed as such, so that on analysing the supernatants lower calcium values are found.

This would also explain the lowering in calcium concentration found by Karshan.

To test this theory a suspension of calcium caseinate (Casec-Meads) was analysed for calcium and phosphorus using the tri-chloroacetic acid filtrate. It was then shaken with excess calcium phosphate and the centrifugate analysed for calcium and phosphorus. The results are shown in Table IV.

TABLE IV

EFFECT OF SHAKING CASEC (MEADS) WITH CALCIUM PHOSPHATE

Before Shaking		After Shaking	
Calcium	phosphorus	Calcium	Phosphorus
mg. %	mg. %	mg. %	mg. %
11.5	0.31	6.9	17.2

These results indicate another possible explanation for Karshan's results and suggest that a possible difference between caries-free and caries-active salivas is the form in which calcium is present. These results would suggest that in caries-free salivas there is a larger proportion of calcium proteinates than in salivas from caries-active individuals.

PROPOSED WORK

(1) Karshan's results seem to depend on the form of calcium (inorganic or organic) present in saliva, therefore it is proposed to investigate the effect of protein precipitants on the calcium content of salivas:

(2) Purify salivary phosphatase by dialysis or precipitation.

-
- (1) J. Dent. Res. 15, 383, 1936.
 (2) J. Dent. Res. 18, 395, 1939.

APPENDIX "B"

CRITIQUE OF METHODS USED IN DETERMINING THE WATER VAPOUR CONTENT OF NITROUS OXIDE.

R.J.S. TICKLE B.D.S. (SYD.), D.D.S. (TOR.).

DR 2

SUMMARY

Purpose

The purpose of this research was to investigate the water content of anaesthetic nitrous oxide and to compare the method given in the B.P. 1932 for measuring the water content of this gas with other methods of determining water vapour in gases.

Scope

When the B.P. method using an ordinary phosphorus pent-oxide tower and using rubber tubing for leading gas from the cylinder containing the nitrous oxide to the tower was tried, much difficulty was experienced in obtaining anything like uniform results. Improvements in the type of tower and the use of glass tubing with wax-coated rubber joints or vinyl acetate tubing for making joints, reduced the variation in results but at best the greatest standard deviation was ± 0.05 mg. per litre.

A second method in which water vapour was removed by passing the gas slowly through a suitable tube immersed in a freezing mixture just above the liquefying temperature of nitrous oxide, gave more uniform results, especially when the water was estimated by titration with the Karl Fischer reagent. When attempts were made to estimate the water by weighing, very irregular results were obtained. The greatest standard deviation for this method was ± 0.02 mg. per litre. Increasing the rate of flow of gas from 2 to 4 litres per hour did not alter results.

The dew point hygrometer method used for the estimation of water vapour in aviation oxygen was employed but results were very low. It was felt that this method was unsatisfactory for nitrous oxide, since it is doubtful whether at the rate of 15 litres per minute a state of equilibrium is reached between the water vapour and the liquid phase of nitrous oxide in the nitrous oxide cylinder. Also it must be remembered that the measurements were made near the liquefying conditions of temperature and pressure of nitrous oxide.

Conclusions

The water content of nitrous oxide, as manufactured in Canada, appears to be about 5% of the limit set in the B.P.1932.

The water content of anaesthetic nitrous oxide did not vary greatly amongst individual cylinders examined.

In any method of water vapour determination, the rate of flow and the minimum amount to be tested should be stipulated. The use of rubber tubing connections is contraindicated.

The freezing out titration method appears to give more consistent results than the phosphorus pentoxide method in the estimation of small amounts of water vapour in small volumes of nitrous oxide.

The use of the dew point hygrometer is not recommended for the determination of water vapour in nitrous oxide.

The water vapour content of nitrous oxide is in no way great enough to be of significance in the use of the gas as an anaesthetic in Dentistry or Medicine.

September 26, 1946.

"Geo. H. W. Lucas"

CRITIQUE OF METHODS USED IN DETERMINING THE WATER VAPOUR CONTENT OF NITROUS OXIDE.

R.J.S. TICKLE B.D.S.(SYD.), D.D.S.(TOR.).

Since nitrous oxide is used as a general anaesthetic on a large scale in medicine and dentistry, its purity must be carefully controlled. In Canada nitrous oxide gas for anaesthetic purposes must meet the specifications of the B.P.1932 (1) limiting the amount of water vapour to 2 mgm. per litre. The method for this estimation as set down in the B.P. involves the absorption of water vapour by phosphorus pentoxide. The nitrous oxide is led from a cylinder to a tared absorbing tower filled with phosphorus pentoxide, through which a measured quantity of gas is passed at an unspecified rate. The increase in weight is attributed to the absorbed water vapour.

This method as used in the Department of Pharmacology, University of Toronto, from time to time frequently gave inconsistent results, so much so that a check was carried out by the Department of Physics, University of Toronto, using the dew point hygrometer. The water content given by the dew point method was considerably smaller than results obtained by the B.P. method. This difference was so great that an investigation seemed warranted.

The official method was carefully examined and a number of possible sources of error noted. One was the difficulty associated with the accurate weighing of the gas tower before and after the experiment. Another was the design of the gas tower, which seemed important not only for the adequate dispersion of the gas through the phosphorus pentoxide and prevention of the gas from channelling in fixed paths, but to ensure the same volume of gas in the tower before and after the experiment. Since 1 cc. of nitrous oxide at N.T.P. weighs 1.97 mgm. (2), it is obvious that any loss would result in changes in weight. The method of leading the gas from the nitrous oxide cylinder to the tower and in to the gasometer was examined. This usually involves the use of rubber tubing. It is known, and readily demonstrated, that nitrous oxide diffuses rapidly through rubber and consequently this should interfere with the accuracy of measurement of the total volume of gas. Finally, the rate of flow was thought to be of some importance.

In consequence of these difficulties and uncertainties it was decided to change the method of water estimation. One was evolved which used the principle of freezing out the water vapour in a suitable trap and estimating the amount quantitatively by titration, using the sensitive Karl Fischer reagent for the determination of water (3, 4, 5).

Freezing out titration method

The nitrous oxide gas was led from a cylinder into a gas trap immersed in a freezing mixture and on to a gasometer by means of glass tubing, using a minimum of polyvinyl acetate tubing connections covered with laboratory wax. The freezing mixture used was one of CHCl_3 CCl_4 dry ice, which reduced the temperature to -79° , approximately 10° above the liquefying point of nitrous oxide. The trap was so designed as to permit immediate titration of the frozen out water vapour by the addition of Fischer reagent directly into the trap in a closed circuit containing nitrogen.

In order to test the accuracy of this procedure, a series of analyses were made to determine the water vapour content of medicinal oxygen, for which accurate figures had been obtained using the dew point hygrometer. These results are shown in Table I.

TABLE I Oxygen cylinder 108394

Dew point hygrometer	mgm. water vapour per litre	Rate of flow
	0.23	15 l./min.
	0.26	"
Freezing out, titration	0.26	3.5 l./hr.
Fischer Reagent	0.28	3.0
	0.25	4.0
	0.29	3.0
	0.29	2.8
	0.28	3.0

These figures (and consequently the method) seemed satisfactory, approximating closely those obtained by the dew point method, and the technique capable of determining with accuracy the presence of 0.02 mgm. per litre of water vapour.

It should be pointed out in these analyses, and in all subsequent ones irrespective of the method, that a volume of 4 litres or more of gas was tested. A series of tests were then made on a number of standard 250 gallon nitrous oxide cylinders with the following results (Table II):-

TABLE II

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
21710	0.12	2.0
	0.11	2.0
	0.10	2.3
	0.11	3.0
	0.08	2.5
	0.10	4.0
	0.11	4.0
	0.08	4.0
D35051	0.10	2.5
	0.11	4.0
	0.07	3.5
	0.05	4.0
	0.06	3.8
	0.05	2.5
	0.08	2.8
	0.06	3.0
D29050	0.12	2.5
	0.09	3.5
	0.08	2.8
	0.05	4.0
	0.05	3.8
	0.08	3.0
	0.07	2.5
D11511	0.17	3.0
	0.10	4.0
	0.09	2.5
	0.08	3.0
D109937	0.12	2.0
	0.07	2.8
	0.07	2.5
	0.06	4.0
14159	0.10	2.5
	0.10	2.0
	0.11	2.0

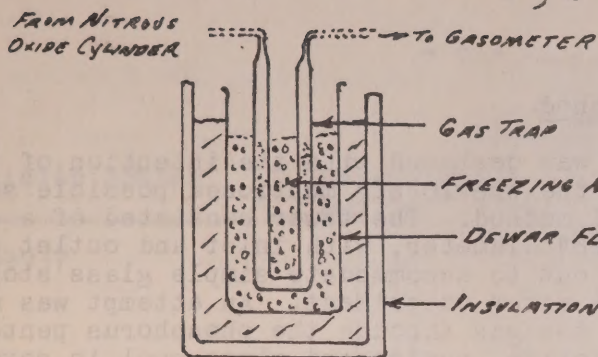
These results indicate that the first samples drawn from any fresh tank are somewhat higher in water vapour than subsequent ones. The figures analysed statistically show this to be so ($P = 0.01$). This point is important in view of the fact that samples must be drawn from a fresh tank of nitrous oxide gas in

the official B.P. method of analysis. We find that if the first reading in all results is neglected the greatest standard deviation for any set of readings is ± 0.02 mgm. per litre (for tank D35051). Also neglecting this first result it will be found that there is no appreciable difference in the percentage of water vapour with the rate of flow varying from 2-4 litres per hour (see Table III).

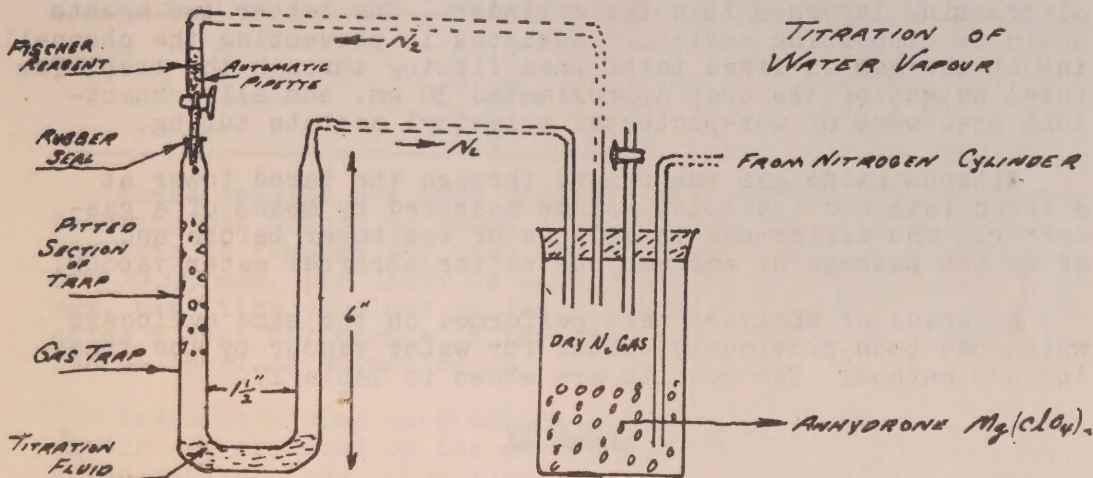
TABLE III

Mean percentage water vapour mgm. per litre					
Rate of flow 3-4 l./hr.	0.10	0.07	0.07	0.09	0.07
203 l./hr.	0.10	0.065	0.075	0.09	0.06
Cylinder No.	21710	35051	29050	11511	109937

The possibility of incomplete removal of water vapour by this method was considered. In order to determine this, a control trap was placed in series with the main trap, both gas traps being immersed in the same freezing solution. A series of analyses were made and results of 0.01 mgm. per litre or less were obtained for the control trap. The figures were very small, at or beyond the titration limits of the reagent and the gas could thus be considered dry. Using this freezing out titration technique, several points must be observed. Absolute dryness of the gas trap and connections is essential. The pitting of the trap walls creates turbulence and was satisfactory in that it was noted that all water vapour froze out in the first half of the trap. The diagram which follows indicates the type of gas trap and circuit that was used in these experiments.



APPARATUS FOR
FREEZING OUT
WATER VAPOUR



TITRATION OF
WATER VAPOUR

Phosphorus pentoxide method

An absorption tower was designed with the intention of trying to overcome some of the previously mentioned possible sources of error in the official method. The tower consisted of a cylinder of glass 6" long, 5/8" diameter, with inlet and outlet ends of capillary bore drawn out to accommodate simple glass stoppers for insertion before and after experiment. An attempt was made to secure dispersion of the gas through the phosphorus pentoxide by using phosphorus pentoxide, pumice and glass wool in several alternating layers within the cylinder. The latter two agents acted as dispersing media and assisted in preventing the channelling of the gas in fixed paths when flowing through the trap. The total weight of the trap approximated 30 gm. and all connections used were of wax-protected polyvinyl acetate tubing.

Nitrous oxide gas was passed through the tared tower at a known rate and the total volume measured by means of a gasometer. The difference in weights of the tower before and after the passage of gas was due to the absorbed water vapour.

A series of analyses were performed on the same cylinders which had been previously tested for water vapour by the freezing out method. The results are shown in Table IV.

TABLE IV

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
D35031	0.07	3.0
	0.10	4.0
	0.12	4.0
	0.08	2.5
	0.00	3.0
	0.15	irregular
	0.08	3.0
29050	0.04	4.0
	0.05	4.0
	0.22	4.0
	0.06	4.0
	0.09	4.0
11551	0.05	3.0
	0.00	2.5
	0.10	4.0
	0.16	2.5

TABLE IV (Cont'd)

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
D109937	0.00	4.0
	0.10	3.0
	0.10	3.5
	0.18	3.0
	0.13	3.0
14159	0.14	4.3
	0.08	4.0
	0.21	4.0
	0.07	3.5

These results are more variable than those obtained by the freezing out method as shown by comparing with Table II. An analysis of figures for tank D35031 shows a standard deviation of ± 0.05 mgm. per litre as compared with the figure of ± 0.02 mgm. per litre obtained by the freezing out method. This indicates a real difference in the precision of the two methods at the 3% level of significance.

Tests were then carried out to determine whether all water vapour was absorbed by the phosphorus pentoxide (6,7) at the given rate of flow, thus also checking dispersion and channelling. The nitrous oxide having passed through the phosphorus pentoxide tower, was led into a gas trap submerged in a cooling solution and an estimate made as in the titration method previously described. A series of tests failed to determine the presence of water vapour in the gas trap.

The problem of diffusion of nitrous oxide gas was considered. Tests were carried out in which the gas was led from the cylinder to the tower through 12" of unwaxed black gum rubber tubing, 3/16" bore and 1/16" wall. Figures are shown in Table V.

TABLE V

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
21710	0.30	4.0
	0.30	4.3
	0.16	3.0
	0.24	4.0
mean 0.25 mgm./l.		

The rubber connection was lengthened to 30" with the following results (Table VI).

TABLE VI

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
21710	0.38	4.0
	0.51	2.0
	0.40	4.0
	0.25	4.0
	0.11	4.0
	0.30	3.8

Mean 0.32 mgm./l.

Following these experiments the rubber tubing connections were replaced by a minimum amount of wax-coated polyvinyl acetate tubing and a further series of tests carried out on the same cylinder. The results are shown in Table VII.

TABLE VII

Cylinder number	Water vapour mgm. per litre	Rate of flow litres per hour
21710	0.18	4.0
	0.11	2.5
	0.07	3.0
	0.03	3.8
	0.02	2.8
	0.17	3.6
	0.08	3.0
	0.07	3.8
	0.15	4.0

Mean 0.1 mgm./l.

A comparison of figures in Tables V, VI and VII shows clearly that there is a progressive gain in the amount of water vapour when the length of rubber tubing is increased. However, allowing for diffusion of nitrous oxide, the gain in weight does not seem proportional to the amount of gas collected. It was suspected that water vapour might diffuse from the atmosphere into the dry gas passing through the rubber tubing, or be extracted from the tubing itself.

It should be stated from the results obtained in Table IV and Table VII that the phosphorus pentoxide method described above seem satisfactory for practical purposes of water vapour determination, providing always there is control over the possible sources of error, as previously listed.

It will be seen from the following Table (VIII) that the mean value for water vapour content as determined by the two previously described methods, is relatively the same.

TABLE VIII

Cylinder number	Mean percentage water vapour mgm. per litre	
	Freezing-titration method	Phosphorus pentoxide method
35031	0.06	0.085
29050	0.07	0.09
109937	0.08	0.10
14159	0.10	0.13
11551	0.09	0.08
21710	0.09	0.10

Dew point hygrometer method

The third means employed in the determination of water vapour in nitrous oxide was by using the dew point hygrometer (8). Through the courtesy and aid of the Department of Physics, University of Toronto, analyses were made on several tanks of gs. The results obtained are shown in Table IX.

TABLE IX

Cylinder 35031 - a. 0.02 mgm. per litre b. 0.02 + mgm. per litre
Cylinder 21710 - a. Water content less than 0.02 in several analyses and not measurable, owing to liquefaction of the gas.

These figures, as obtained with the oxygen calibrated hygrometer, are low. A probable reason is that the rate of flow used is 15 litres per minute, and it is doubtful whether at this rate

there is a state of quillibrium between the water vapour and the liquid phase of the nitrous oxide in the cylinder. It must also be remembered that the measurements were made near the liquefying conditions of temperature and pressure of the gas.

Conclusions

The water content of nitrous oxide, as manufactured in Canada, appears to be about 5% of the limit set in the B.P.1932.

The water content of anaesthetic nitrous oxide did not vary greatly amongst individual cylinders examined.

In any method of water vapour determination, the rate of flow and the minimum amount to be tested should be stipulated. The use of rubber tubing connections is contraindicated.

The freezing out titration method appears to give more consistent results than the phosphorus pentoxide method in the estimation of small amounts of water vapour in small volumes of nitrous oxide.

The use of the dew point hygrometer is not recommended for the determination of water vapour in nitrous oxide.

The water vapour content of nitrous oxide is in no way great enough to be of significance in the use of the gas as an anaesthetic in Dentistry or Medicine.

Acknowledgments

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A COMPARISON OF THE GAS PERCENTAGE DELIVERY AND PERCENTAGE DIAL SETTING IN ANAESTHETIC GAS MACHINES. A PRELIMINARY REPORT.

R.J.S. TICKLE B.D.S.(SYD.), D.D.S.(TOR.).

DEPARTMENT OF PHARMACOLOGY, UNIVERSITY OF TORONTO.

DR 2.

SUMMARY

Purpose

This preliminary investigation was made to recheck some gas analyses obtained in this Department in which it was found that some anaesthetic machines did not deliver accurately the gas mixtures indicated by the percentage dial setting. A general survey of machines in dental offices was under consideration and if some machines were found defective, using the chemical gas analytical methods, a general survey could be undertaken without delay when the gas analyser, on order, reached the Department.

Scope

The gas mixtures delivered by three machines in general use for the administration of nitrous oxide-oxygen mixtures were analysed, using a 10% pyrogallol in strong potassium hydroxide saturated with nitrous oxide. In two machines the gas delivered under anaesthetic conditions agreed very closely with the theoretical (dial setting) up to 20%. Beyond this, the percentage delivered was several percent below the theoretical.

A third machine delivered about 50% of the theoretical.

Conclusions

Further investigation into the various types of gas machines and their accuracy seemed warranted, especially as the average dental practitioner cannot be considered a skilled anaesthetist.

A more rapid method whereby machines could be tested, seemed essential to any general survey.

Sept. 26, 1946.

"George H. W. Lucas"

A COMPARISON OF THE GAS PERCENTAGE DELIVERY AND
PERCENTAGE DIAL SETTING IN ANAESTHETIC GAS MACHINES.

A PRELIMINARY REPORT.

R. J. S. TICKLE

DEPARTMENT OF PHARMACOLOGY, UNIVERSITY OF TORONTO.

It is a well established fact that true surgical anaesthesia cannot be obtained without some degree of anoxemia, when nitrous oxide-oxygen mixtures are given without adequate premedication. Such a circumstance is obviously dangerous to both patient and operator. Frequently in the hands of the unskilled anaesthetist this condition of anoxemia has progressed to anoxia, asphyxia and occasionally death. In one such recorded case, death was attributed in part to a faulty gas machine, for when it was tested in this Department it did not deliver the percentages of nitrous oxide-oxygen as indicated by the percentage regulating dials.

In view of these facts and the obvious increase in dangers involved in the administration of nitrous oxide-oxygen by the careless or unskilled anaesthetist using a faulty machine, it was considered advisable to determine the reliability of gas machines now in use to deliver accurately gas mixtures of the same percentage as that indicated by the regulating dials. For this purpose an accurate gas analyser was considered and purchased but delivery was long delayed. It was therefore decided to do some preliminary testing on three different machines available, using a Hempel pipette and burette.

It had been previously found in experiments conducted in this Department, that if a solution of 10 gm. of pyrogallol in 100 cc. of a saturated potassium hydroxide solution were saturated with nitrous oxide, this could be used in a Hempel pipette with accuracy and without correction to measure the amounts of oxygen in a nitrous oxide-oxygen mixture.

The gas machines were set to function as under normal conditions during anaesthesia and samples were drawn at a point after the gas had passed through the mixing chamber or bag and a system of baffles inserted to ensure complete mixing of the gases.

The oxygen-nitrous oxide ratio was gradually increased and samples of gas were analysed. A series of results were obtained for each machine.

Gas Machine A

The following Table gives one series of results obtained for this machine.

TABLE I

Reducing valves set at same figure as when gas delivered at 7 mm. pressure to patients

Theoretical O ₂ % delivery	5	10	15	20	25	30	40
Actual O ₂ % delivery	3.8	7.9	8.2	11.5	14.0	15.6	21.5

It will be observed that the theoretical and actual deliveries did not approximate. In the use of this machine it is advised by the makers that the pressure shown by the reducing valves be set at approximately the same figure between 40 and 60 for both nitrous oxide and oxygen. During anaesthesia and the flow of gas there is a tendency for the needles of the reducing valves to oscillate and vary, one cause being the expiration of the patient into the semi-closed circuit. Experimentally it was found that should the pressure recorded on the reducing valves vary from 10-20 degrees during anaesthesia, the percentage of oxygen delivered varied greatly.

Thus if the oxygen reducing valve is 10-20 degrees below that of the nitrous oxide reading, the oxygen delivery may well be 25-50% below that obtained when both settings are the same. The reverse also applies. With the oxygen reading 10-20 degrees higher than the nitrous oxide reading, the percentage recovery of oxygen may be up to 50% greater than the figures in Table I.

Gas Machine B

The following figures (Table II) indicate the percentage of oxygen obtained from the oxygen-nitrous oxide sample delivered under normal anaesthetic conditions of flow and pressure in the open method of administration.

TABLE II

Reduction valve readings at the same mark when gas delivered at 3 gals. per minute

Theoretical O ₂					
% delivery	7	10	15	20	25
Actual O ₂					
% delivery	7	10.4	15.1	19.7	22.7

It is obvious from these results that this machine was quite accurate up to the 20% oxygen mark. Tests involving the changing of the pressure in the reduction valves during flow did not result in any appreciable differences in the percentage recovery.

Gas Machine C

This popular type of machine differed from the type previously examined in that there were no visible reduction valve pressure gauges. Working under conditions previously described when using Machines A and B, samples of gases were analysed, giving the following results (Table III).

TABLE III

Rate of flow 3 gals. per minute

Theoretical O ₂					
% delivery	7	10	15	20	25
Actual O ₂					
% delivery	8.2	11.3	14.6	17.7	20.8

It will be seen that these figures are somewhat higher than the true expected percentages up to 15% oxygen and from this point there is a gradual decrease in the values obtained. However, the deviation could not be considered to be of great clinical significance. The problem was then considered as to whether a marked decrease in the pressure in either of the two gas cylinders would produce a change in the percentages obtained during gas flow. The nitrous oxide cylinder was practically exhausted and a series of tests performed after the manner previously described. Even in this case, deviations from the theoretical were not serious.

Conclusions

The A type of gas machine delivered approximately 50% of the expected value. Changes occurred readily on the reading of the reduction valve scale, resulting in irregular percentage deliveries. The possibility that this machine was mechanically defective must be taken into consideration when attempting to estimate its accuracy.

Type B gas machine could be considered accurate and type C relatively so.

Further investigation into the various types of gas machines and their accuracy seemed warranted, especially as the average dental practitioner cannot be considered a skilled anaesthetist.

A more rapid method whereby machines could be tested, seemed essential to any general survey.

APPENDIX "D"

INTERIM REPORT ON PROJECT DR 4

Investigation of Packing Material in the Treatment of Periodontal Disease

by

Dr. Harold K. Box

1. Introduction

It has often been stated that the most important prerequisite for the existence of "pyorrhea" is the presence of a pocket. The implication, of course, is that the formation of the pocket precedes the suppuration to which in the past so much attention has been given. This idea places the pocket in a "causative" category, and stresses to some degree the occurrence of pus-production. More significant, however, is the fact that the pocket has arisen as a "result" of certain causes. Elucidation of this problem - viz., how the pocket is formed in the first place, is the crux of one of the most important phases of periodontal disease.

Pocket deepening, apart from increase of depth caused by gingival swelling, takes place by a shifting of the pocket base towards the apex of the tooth. This event, as far as we know at the present time, always takes place in the epithelial attachment, that is to say, the actual deepening of the pocket is confined to the epithelial attachment.

This structure is comprised of a few layers of stratified squamous epithelium which form a collar-like band uniting the soft tissues and the tooth. The epithelial attachment on the enamel is a residue of the enamel organ, and is formed there after the enamel is completed and before it erupts. Its first presence on the cementum is due to proliferation and extension of the enamel epithelium on the surface of the root, from which, once more, further downgrowths can take place.

While pocket extension actually occurs in the epithelial attachment through loss of some of its epithelial cells, in the broader picture, this is made possible on an extensive scale as part of a progressing periodontal disease, by new epithelial downgrowths on the cementum. These downgrowths occur following loss of fibrous connective tissue attachment to the cementum adjacent to the base of the epithelial attachment. This detachment of connective tissue fibres may be manifested as a slow and gradual process, or it may occur as a severe and sudden process with destruction of whole fibre-bundles at a time.

In the first case obviously the pockets tend to form slowly, and the clinical picture reveals them on the whole, as broad and shallow in the earlier stages. The teeth also tend to remain firm in their sockets until late in the disease. Abundant hard and soft deposits are usually present, the gingival tissues are markedly inflamed, and the mouth presents a picture of uncleanness.

In the second case, the pockets are usually formed with greater rapidity, and in many instances they tend to be deep and narrow. In other instances, they progress by tending to encircle the tooth. Dependent on several conditions, chiefly the marked widening of the periodontal membrane over a large area, the tooth may show mobility at an early stage. Paradoxically, this peculiarly destructive form of periodontal disease is frequently found in comparatively clean mouths, and with the gingival tissues showing little clinical inflammation.

The difference in destructive intensity and rate of progress of periodontal disease found in well-cared-for mouths is a feature of particular significance. In the unclean mouth with its myriads of organisms of various kinds, the stronger necrotizing types appear to be restrained in some manner. In the clean mouth, through elimination of countless weaker forms, the stronger organisms apparently tend to rapidly proliferate and become dominant.

The prevailing teaching of today, in the second class of periodontal disease, attributes the primary cause of detachment of connective tissue fibres from the tooth to more-or-less obscure general metabolic factors. These deeper destructive changes are regarded as primary, and in no way related to events taking place in the pocket.

According to our recent investigations, it seems probable that deep fundamental lesions involving the periodontal membrane and alveolar bone are brought about by agents arising in the pocket. This is not to infer that general metabolic states are not involved as predisposing causes. It is more or less generally agreed that the destructive changes in the epithelial attachment are caused by organisms in the pocket. The new hypothesis extends this concept, and ascribes, in the majority of cases, the destruction of the fibre-bundles, on the tooth surface where they are attached, as well as away from the surface, to the same etiologic source.

There is evidence to support a working hypothesis that certain fungus-like organisms and associated free bacillary forms which develop in the pocket, or sulcus, have a direct causative relation with destructive changes in the pocket such as necrosis of the epithelial attachment and cuticle destruction.

Through elaboration of necrotizing enzymes in the pocket, and their carriage, probably by the lymphatics, to the deeper tissues where they are liberated, localized and widespread destructive changes are brought about.

The presence of visible pus in the pocket has held a place of great prominence in dental literature for many years. This is shown in the popular term "pyorrhea" which still persists in spite of the fact that it depicts a symptom which may or may not be present. The great majority of pockets are free from visible suppuration especially in their early stages, and we regard its occurrence in a pocket as a secondary process superimposed on, or having replaced, a primary necrotic one.

One implication of this newer conception of periodontal disease becomes immediately apparent. The pocket assumes a position of much greater significance. With emphasis placed on necrotizing processes rather than suppuration, and with deep destructive changes in the periodontal membrane ascribed directly to factors of extrinsic origin, pocket therapy takes on a new meaning. This brings us to our present problem.

2. Problem - -

To investigate the use of cement packing materials in the treatment of periodontal disease.

Throughout all the work, attention was given to the dual possibility of this study, namely that besides studying therapy, the investigation of etiology through therapy was kept in mind in the planning of the studies.

During the last five years, the use of germicidal cement as a packing or dressing material in the treatment of gingivitis and periodontitis has shown a steady and rapid increase in Canada. This is unquestionably due to its effectiveness in these conditions combining as it does, a fairly high capacity to kill microorganisms, desirable mechanical properties, with a marked stimulation of soft tissue circulation. Further the techniques employed are well within the scope of the average dental practitioner; the materials are comparatively inexpensive; and no special dental equipment is required.

3. Scope

The beneficial effects of this material may be ascribed to at least three possibilities, (1) bactericidal effect, (2) mechanical effect and (3) the therapeutic action on the tissues.

The investigation so far has been largely on the bactericidal properties. "In vitro" and "in vivo" studies were carried out.

(A) "In vitro" studies.

The materials which were investigated were the powders: Zinc Oxide, Tannic Acid, Resin, Kaolin and Asbestos; and the liquids: Eugenol, Thymol and Sweet Almond Oil.

The bactericidal properties of the materials were studied singly and in combination. The following is a brief report of the investigations.

Using the "agar-plate-with-gutter technique" and blood agar, as used in Penicillin Sensitivity testing, the bactericidal effect of the ingredients of both powder and liquid used singly and in combination were studied. These tests were carried out against *Staphylococcus aureus*.

Two criteria are reported, first a band of discolorization of the blood agar which will be referred to as the chocolate zone, as that was its color, and, second, a band of inhibition of bacterial growth.

I. The following chart gives the results of tests on the powders, using water as the liquid and asbestos as a binder.

	<u>Chocolate Zone</u>	<u>Inhibition Zone</u>
Asbestos + H ₂ O	0	0
Asbestos + Zinc Oxide + H ₂ O	0	1
Asbestos + Resin + H ₂ O	0	0
Asbestos + Tannic Acid + H ₂ O	13	5
Asbestos + Zinc Oxide + Tannic Acid + H ₂ O	0	2

Findings

(a) Very little bactericidal properties were exhibited by the powders with the exception of Tannic Acid which gave 5mm. inhibition.

(b) Tannic Acid with asbestos caused a 13 mm. chocolate zone.

(c) With the addition of Zinc oxide this chocolate zone was reduced to zero.

II. In testing the oils, water, of course, was omitted but asbestos was again used as a binder. The oils studied separately and in combination were: Eugenol, Eugenol and Thymol, and Eugenol and Sweet Almond Oil. Eugenol and Zinc oxide set to form a hard cement in the presence of water. Wherever these two ingredients are present the mixture set to form a hard cement.

1. The following chart gives the results when Eugenol alone was tested.

	<u>Chocolate Zone</u>	<u>Inhibition Zone</u>
Asbestos + Eugenol	9	14
Asbestos + Zinc Oxide + Eugenol	4	8
Asbestos + Zinc Oxide + Resin + Eugenol	12	21
Asbestos + Zinc Oxide + Tannic Acid + Eugenol	9	12
Asbestos + Zinc Oxide + Resin + Tannic Acid + Eugenol	11	13

Findings

(a) When Zinc oxide is added to asbestos and Eugenol resulting in the mixture setting, the chocolate zone was reduced, also the zone of inhibition.

(b) On the addition of Resin to the asbestos, Zinc oxide, Eugenol mixture, both the chocolate zone and zone of inhibition were increased.

(c) With the addition of Tannic Acid to the mixture the chocolate zone remained the same but the zone of inhibition was reduced.

2. The next chart gives the results when Eugenol and Thymol were used. (98 parts of Eugenol and 2 parts Thymol).

	<u>Chocolate Zone</u>	<u>Inhibition Zone</u>
Asbestos and liquid	12	22
Asbestos + Zinc Oxide + Liquid	6	27
Asbestos + Zinc Oxide + Resin + Liquid	13	25
Asbestos + Zinc Oxide + Resin + Tannic Acid + liquid	10	12

Findings

(a) With asbestos alone both chocolate zone and zone of inhibition were increased over asbestos and Eugenol.

(b) With the addition of Zinc oxide to the above, the chocolate zone was decreased and zone of inhibition increased.

(c) Again, on the addition of Resin to the mixture the chocolate zone was increased.

(d) Again with the addition of Tannic Acid, the zone of inhibition was reduced.

3. The last chart in this series gives the results when Eugenol 75% and Sweet Almond Oil 25% were tested. The addition of Sweet Almond Oil reduces the time of setting and makes the mix easier to handle.

	<u>Chocolate Zone</u>	<u>Inhibition Zone</u>
Asbestos + Liquid	8	14
Asbestos + Sweet Almond Oil	5	5
Asbestos + Zinc Oxide + Liquid	13	21
Asbestos + Zinc Oxide + Resin + Liquid	11	24
Asbestos + Zinc Oxide + Resin + Tannic Acid + liquid	8	12
Asbestos + Zinc Oxide + Tannic Acid + liquid	8	10

Findings

(a) This liquid and asbestos give the same zones as does asbestos and Eugenol.

(b) The Sweet Almond Oil alone and asbestos give zones of 5 mm. each.

(c) The addition of Zinc Oxide increases the zone of inhibition and also the chocolate zone.

(d) The addition of Tannic Acid to the mixture decreases the zone of inhibition.

4. In all cases the zone of inhibition occurred within a 24 hour period. There seemed to be two processes going on at the same time, namely the diffusion of the germicide and the growth of the organism. The questions arise as to how long the material would continue to diffuse germicide and whether the organisms, which had grown beyond the zone of inhibition, were dead or alive. Accordingly after two days at room temperature after the initial 24 hour incubation at 37.5°C, five plates and one control were restreaked with *Staphylococcus aureus* and re-inoculated. There was no growth on any portion of any plate except the control plate. Evidently diffusion of germicide continued on the plates.

In order to check this fact and also to find out if setting interfered with the germicidal action, the following studies were carried out.

5. To Test the diffusion of germicide in various lengths of time and to study the effects of setting on the diffusion. Five grams of pack with Eugenol and Sweet Almond Oil, and the same amount with Eugenol and Thymol, were placed on a swab stick and dropped into 5 cc. of Beef Extracted Broth. After one half hour in first tube, pack was hard and transfer was made from tube to tube at intervals.

Thus:

Tube 1	1/2 hour - pack set
Tube 2	1/2 "
Tube 3	1 "
Tube 4	1 "
Tube 5	24 "

All tubes were then seeded with *Staphylococcus aureus* and incubated at 37.5°C for 24 and 48 hours. No growth occurred in any culture tube.

The next question was whether the result obtained was due to germicide on the surface or actual diffusion from the core of the pack.

6. Therefore in the next test after the pack was allowed to harden in the first tube for one half-hour, it was carried through a series of 6 washes in one hour, ten minutes in each tube and then carried through two one-half hour tubes, two one-hour tubes, one two-hour tube and one twenty-four-hour tube. These tubes were then seeded and incubated for 24 hours. No growth appeared in any tube. On 72 hours incubation, the last four wash tubes only showed evidence of growth. It appeared then that time for diffusion was necessary.

7. To determine if the *Staphylococcus aureus* had been killed or only inhibited, four tubes of fresh sterile broth were seeded from one half-hour tubes in diffusion series and incubated at 37.5°C for 48 hours. No growth occurred in any tube.

8. The last study was carried out to determine how long the pack would continue to diffuse germicide. This test was carried out in duplicate according to the method described above.

The pack was placed in broth and incubated for 24 hours. At the end of this time, pack was removed and placed in next broth tube and incubated for one hour. Following this, pack was transferred to another tube and incubated for another 24 hours. This procedure was continued each day. Day by day the tubes, from which pack had been removed, were seeded with *Staphylococcus aureus* and incubated for 24 hours. Up until the 24th day, no growth had occurred in either the one hour or 24 hour tubes. This test is being continued. It is evident from this experiment that sufficient germicide diffuses from the pack in one hour after 24 days in broth to stop the growth of the organism.

(B) "In Vivo" Studies

I. To study the effect of packing in 24 and 48 hours.

Procedure:- Material taken from the depths of periodontal pockets was smeared on slides and allowed to dry in air. After drying the smears were stained according to Giemsa's method.

These smears were examined under oil very carefully, at least 30 fields being considered in thin preparations.

For practical purposes, the microscopic findings were divided into three groupings.

Those smears in which no organisms of the fusospirochetal group were found, after careful observation, were called Clinically Sterile. Those smears showing only one or two organisms per field were called Almost Clinically Sterile.

Those smears which were laden with any of the group organisms in fair number were called Clinically Septic.

Before-treatment and after-treatment smears have been examined to date on 64 pockets, of which the depth varied between 4 and 7 mm. All the "before-treatment-smears" were found to be Clinically Septic.

Of the "after-treatment-smears" taken from pockets following packing with periodontal pack described earlier;

70.3% were Clinically Sterile

12.5% were Almost Clinically Sterile
and

17.2% were Clinically Septic.

II. To study the effect of packing in 4 - 7 days.

Procedure: - The same procedure was carried out in this study except that the pockets were packed for longer periods.

The results were as follows:-

On 32 cases only, "after-treatment-smears" showed that;

50% were Clinically Sterile

37.5% were Almost Clinically Sterile

and

12.5% were Clinically Septic

III. To study the effect of packing after pack had been removed from pocket 7 - 28 days in partially treated mouths.

The procedure was similar to that of previous studies made "in vivo".

The results were as follows:

On 9 cases only, "after-treatment-smears" showed that:

One case was Almost Clinically Sterile

Four cases were much improved

and

Four cases were Clinically Septic.

IV. To determine relative values of physical and chemical agents.

Materials used in test

(a) Water

(b) Eugenol

(c) Eugenol and Thymol

(d) Eugenol and Sweet Almond Oil

Method

Liquid is taken up in cotton batting, packed into pocket and sealed in with regular pack for 24 hours.

Before and after treatment smears were taken and examined in same way as in previous studies.

The results were as follows:

24 hours

- (a) Cotton and water - 2 cases - pockets - Clinically Septic.
- (b) Cotton and Eugenol - 1 case - pocket Improved.
- (c) Cotton and Eugenol and Thymol - 1 case - pocket Improved.

72 hours.

- (d) Cotton, Eugenol and Sweet Almond Oil - 2 cases - Clinically Sterile.
- (e) Cotton, Eugenol and Thymol - 1 case - Almost Clinically Sterile.

V. Time factor consideration for determination of pack effect.

In this study the pack was used and before and after treatment smears were stained and studied as before.

The pack was in the pocket from one-half-hour to 48 hours.

The results of this study were as follows:

- One case 1/2 hour - Almost Clinically Sterile
- One case 2 hours - Improved
- One case 24 hours - Clinically Sterile
- One case 48 hours - Clinically Septic

Study (c)

Our present aim, based on the foregoing findings, is to increase the effectiveness of germicidal cement used in the treatment of pockets. We must take into account certain findings as revealed in pocket histopathology, and certain laws that govern disinfection. We know that organisms at the bottom of the pocket are protected by cellular debris in various stages of breakdown, and probably by blood serum. It is known that proteins in the media greatly reduce the activity of most germicides. The presence of pus also markedly decreases germicidal activity. It, therefore, is now proposed to repeat certain "in vivo" tests with cement packing in certain cases in which the necrotic tissue and cellular debris have been removed from the pocket before the cement is introduced.

Some of the aims of packing:-

1. Prior to sealing - to reduce the danger of forcing organisms into the deeper soft tissues.
2. Prior to extraction - to prevent or reduce bacterial showers in the blood; and to prevent the occurrence of necrotic sockets and cellulitis.
3. Prior to gingivectomy - to prevent forcing organisms into blood vessels.
4. To bring the progress of early periodontal disease to a halt; or to prevent its inception.
5. To increase the chances of reattachment through more prolonged retention of the blood-clot.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4602

by D. R. Christie

In the last year an extensive research programme has been conducted in the laboratories of the Ontario Research Foundation on the problems associated with methyl methacrylate denture base material when used in a compression molding technique.

The process of making a denture was learned at the Canadian Dental Corps Training Centre in Toronto with the assistance of Dr. Twible and Major Shenton. Dr. Westman and Mr. Schierholtz visited the Training Centre before the writer and, after they had been introduced to the problems, proposed a series of investigations.

We shall deal with these problems one by one and indicate the information which has been acquired about each of them.

First of all, a description of the Canadian Dental Corps technique for making a full upper denture might be in order so that all concerned will have an appreciation of the steps involved and the problems associated with them.

Description of Canadian Dental Corps Technique

A wax model, complete with teeth and polished to represent the finished denture, is made on an artificial stone cast of the mouth. The model and cast are invested in plaster in the lower half of the dental flask. The wax model is then covered with tinfoil, except for the teeth. The top half of the flask is put in place and the tooth half of the investment plaster is poured. When the plaster has set, the flask is immersed in hot water to melt the wax, the halves of the flask are separated and residual wax is flushed out with hot water. A separating medium of dilute sodium silicate followed by a more concentrated solution of sodium silicate is brushed on the hot cast and allowed to dry as the flask cools.

In the meantime, a mixture of polymer (powder) and monomer (liquid) is made in approximately a 3:1 ratio. When this mix reaches a doughy consistency, it is ready for packing.

In packing the case, enough mixture to fill the mold cavity is put in, covered with wet cellophane and pressure applied slowly. The flask is then reopened, more mixture added and the pressure re-applied. This trial-packing is continued until a smooth denture is obtained and the mixture has flowed into all crevices and depressions of the mold. It may have to be done five or six times.

After the final trial-pack, the cellophane is removed and the flask is closed under pressure of a spring compress. It is then immersed in a water bath which is brought to a boil over a period of one hour and kept at the boiling point for three-quarters of an hour. It is then bench-cooled for 20 minutes and then cooled further in cold running water.

After deflasking, the dentures are trimmed and polished mechanically.

Mixing of Polymer and Monomer

In all our work, except in a few instances, we used the commercially available powder and liquid forms of Lucitone. To prepare them for use as a denture base material, the powder (polymer) and liquid (monomer) are mixed in the ratio of approximately 3:1. This mixture eventually reaches the consistency of a dough and in this condition is ready for use. The time required for this to happen depends on the temperature. At room temperature 20 to 30 minutes is usually long enough. If kept in a refrigerator, such a mix requires a few hours to reach a workable stage and may still be used for several days after that.

Trial-Packing

A considerable saving in time would be gained if trial-packing could be eliminated. In our experience, it is not necessary to trial-pack five or six times in order to condense the mixture. If the first trial-pack is done properly, there will be enough material to fill the mold and also produce a flash. In addition, the material will be compressed enough so that no defects will result in processing. The flash can then be trimmed off, a slight excess added and the flask closed in a spring compress ready for curing. Two closures are the minimum and ideal, and some experience is necessary before this can be achieved.

Shrinkage

There has always been considerable discussion about the problem of shrinkage. The matter requires some clarification.

All materials expand and contract with changes in temperature. In addition, when methyl methacrylate monomer polymerizes its density becomes greater with the result that it decreases in volume. This property is referred to as polymerization shrinkage.

In the Canadian Dental Corps technique, when the processed dentures were removed from their casts they tended to "pinch in" at the heels. To make them fit again, they had to be sprung slightly. This effect is caused by the difference in thermal contractions of the investment and the plastic. The denture wants to contract much more than the investment will allow and it is only when it is removed from its cast that it can do so. This result would not occur if the investment had the same linear coefficient of thermal expansion or contraction. As will be pointed out, however, in the remainder of this discussion and in the next section on water absorption, it is not a serious defect.

Many investigators have measured linear shrinkage (the net effect of polymerization and thermal shrinkage) and it is reported in the literature to lie between 0.3 and 0.4 per cent. It is obvious that if the mold cavity in a dental flask is packed with the powder-liquid mixture so that there is just enough to fill the mold, then on polymerization there will not be enough material to occupy completely all the space. However, if a slight excess is packed in the mold, this shrinkage will be overcome. To prevent the excess from squeezing out between the halves of the dental flask and forcing them apart and in so doing affecting the fit of the denture, several channels may be cut in the land of the investment and extended to the outside by channels in the walls of the flask.

Water Absorption

It should be pointed out that methyl methacrylate polymer absorbs water to the extent of 1 to 2 per cent of its weight. Again, however, the dimensional change accompanying this absorption is the important factor. The linear expansion of methyl methacrylate in saturating with water at 99° F. is between 0.2 and 0.3 per cent. This means that if the curing shrinkage is 0.3 to 0.4 per cent, the net linear change in dimension is of the order of -0.1 per cent. In other words, the expansion due to water absorption nearly compensates for the contraction caused by polymerization and cooling.

Porosity

One of the most commonly occurring defects in processed acrylic dentures is porosity and the most common cause of this porosity is volatilization of the monomer during the polymerization or curing cycle. (The boiling point of the monomer at atmospheric pressure is 213° F.) The reason is that the polymerization process is an exothermic reaction, and the more rapidly it proceeds, the more rapidly is heat generated. Since the plaster investment and the plastic itself are very poor heat conductors, it is quite easy for the heat of reaction to build up in the denture base material. If this happens, porosity is almost inevitably the result.

When porosity occurs, it is more apt to do so in areas where the greatest bulk of resin exists (in the flanges) or in the positions where the resin is nearest to the centre of the investment (in the palate).

Some means must be provided for the heat of polymerization to be conducted away as fast as it develops.

In the usual methods of denture making, the resin temperature can only be prevented from rising too high by keeping the ambient temperature as low as possible until polymerization is nearly complete. After a considerable degree of polymerization has occurred, it is safe to raise the ambient temperature without causing porosity.

Most techniques are adapted to this end. They make use of relatively low water-bath temperatures for considerable lengths of time followed by higher temperatures. The cure used by the Canadian Dental Corps is an example of this technique.

When the investigation first started, it was claimed that a brand of methyl methacrylate produced in England under the trade name of Kallodentine 222 could be processed by immersion in boiling water. However, we have not been able to obtain a sample of this material.

Study of Polymerization Process

When a powder-liquid mixture of methyl methacrylate denture base material is cured rapidly, the following usually occurs. The temperature of the resin increases gradually from its initial temperature to approximately 185° F. where suddenly the temperature increases very rapidly and may rise as high as 280° F. Just as quickly it falls again but in

this short space of perhaps a minute or two the mass of resin has developed severe porosity.

There are several possible methods of controlling this reaction.

(a) Catalysts

The rate of polymerization of methyl methacrylate is increased by heat, by light and by oxygen. The latter is usually provided by means of peroxides such as benzoyl peroxide. Conversely, the rate of polymerization is decreased by anti-oxidants or polymerization inhibitors such as hydroquinone.

We investigated the possibility of controlling the polymerization reaction by the addition of hydroquinone to the monomer used in the powder-liquid mixture. It was found ineffective because although the rate of polymerization was decreased, the heat of reaction was in no way reduced.

(b) Use of Metal Powder in the Investment

The conductivity of the investment plaster can be increased by the incorporation in it of finely divided metal, such as aluminum. This would serve to conduct away the heat of reaction more quickly than plaster alone.

This fact was confirmed by our studies which indicated that when polymerization occurred the peak temperature was reduced. We also found it possible to speed up the rate of curing and yet avoid porosity. However, the use of aluminum powder at our disposal had two drawbacks: (1) a very fine powder tended to produce a weak investment and (2) a smooth mold could not be obtained when a coarse powder (30 mesh) was used.

(c) Thermoducts

The use of a thermoduct in the tooth half of the investment plaster is a well-known device to help conduct away the heat of reaction from the palate area of a denture. The use of a thermoduct in the model half of the investment is not in common use, to the best of our knowledge. Its use, however, serves a similar purpose. To be efficient, the thermoduct used here was designed to fit into the standard artificial stone cast so that only about 1/8 of an inch of stone separated the denture plastic from the thermoduct at all points. In

addition, the bottom of the thermoduct was ground to fit the bottom of the dental flask and so provide close contact for heat conductivity. With these two thermoducts, it is possible to control the heat of reaction very well and prevent excessive peak temperatures.

In practice, several such thermoducts could be part of a dental technician's equipment. As a suggestion, they might possibly be made to correspond to the different impression trays which a dentist requires.

Strains

It is virtually impossible to mold a denture without some internal strains in it. Because the investment, the teeth (porcelain) and the plastic all have different coefficients of thermal expansion, it is impossible to remove strains by an annealing process.

However, all strains are not important from the point of subsequent distortion during use. Only those which relieve themselves and cause the denture to warp are significant. These may be termed active strains, while those of lesser importance may be referred to as passive or latent strains.

If temperature differences occur during polymerization, local strains can quite easily be formed due to differences in degree of polymerization in various parts of the resin.

Similarly, temperature differentials should be avoided in the cooling of a processed denture, therefore slow cooling should be carried out.

If the thermoducts previously mentioned are used, they will accomplish a two-fold purpose: (1) control the heat of polymerization by the elimination of temperature differentials and thus control strains and (2) control cooling in the same way.

There are four ways to study strains:

1. Immersion of a denture in a solvent.

Active strains around the teeth are revealed by this test in the form of checking or crazing.

2. Heating in water.

As the denture base material approaches its softening point, the strains are relieved and warpage occurs.

3. Observation in polarized light.

This test shows both active and passive strains.

4. Observation of any changes in the fit of the denture during service.

The absence of dimensional change does not indicate a strain-free denture, but only that the service conditions were not such as to cause the strains to be relieved.

Since solvents have such damaging effects on processed dentures, it is advisable to keep solvents in any form away from them.

In the literature we found a reference to polishing dentures by means of solvent vapors but the idea was not new here as it had been suggested in the first report on this subject.

However, in the few attempts which we have made to polish dentures by solvent vapors, the result was always extensive crazing of the entire denture surfaces and particularly those areas around the teeth.

In our investigations we have found that dentures will withstand temperatures up to 185° F., for 5 minutes at least, without showing any distortion. Above this temperature the effect becomes increasingly pronounced until at 212° F. distortion is quite severe. This does not mean that the dentures are unsuitable, only that in use they should never be immersed in very hot water.

Strains around porcelain teeth are easily seen under polarized light in a transparent denture. When plastic teeth are used, strains are very greatly reduced. This would seem to be one argument for the use of plastic teeth.

Transverse Strength

The Tentative American Dental Association Specification No. 12 for denture base materials is the result of an investigation carried out at the Bureau of Standards in Washington, D.C., a few years ago.

In that specification, there is a transverse strength test which is particularly useful in evaluating the suitability of a material to be used in denture bases or, indirectly, the suitability of any curing cycle to which a known satisfactory material is subjected.

The specification makes provision to rule out weak materials and brittle materials. The details of this test may be found in Report No. 4609.

"Anti-Porosity Cycle"

It is desirable to process a denture as quickly as possible and avoid porosity and strains at the same time. We have indicated that the use of thermoducts provides a means of controlling the heat of reaction and eliminating temperature differentials which may cause strains. The heating cycle is another very important factor. In our experience, methyl methacrylate can not be processed successfully by immediate immersion in boiling water. This treatment is far too rapid and always produces porosity.

The treatment which we will refer to as the "anti-porosity cycle" is the result of experience gained here together with information found in the dental literature. It is designed to cause an initial partial polymerization of the denture base material without the production of the heat of reaction, followed by complete polymerization during which porosity is avoided and the heat of reaction is controlled by thermoducts.

Specifically, it is as follows:

The dental flask is immersed in a water bath at 120°F. and heated to approximately 175°F. in from 10 to 15 minutes. The flask is then cooled by changing the water-bath to cold tap water (or immersing the flask in another bath). Heating is continued at once to 212°F. in from 25 to 30 minutes and then cooled further in running tap water for 5 minutes before deflasking. Heating at 212°F. need not be continued once the water bath has reached this temperature.

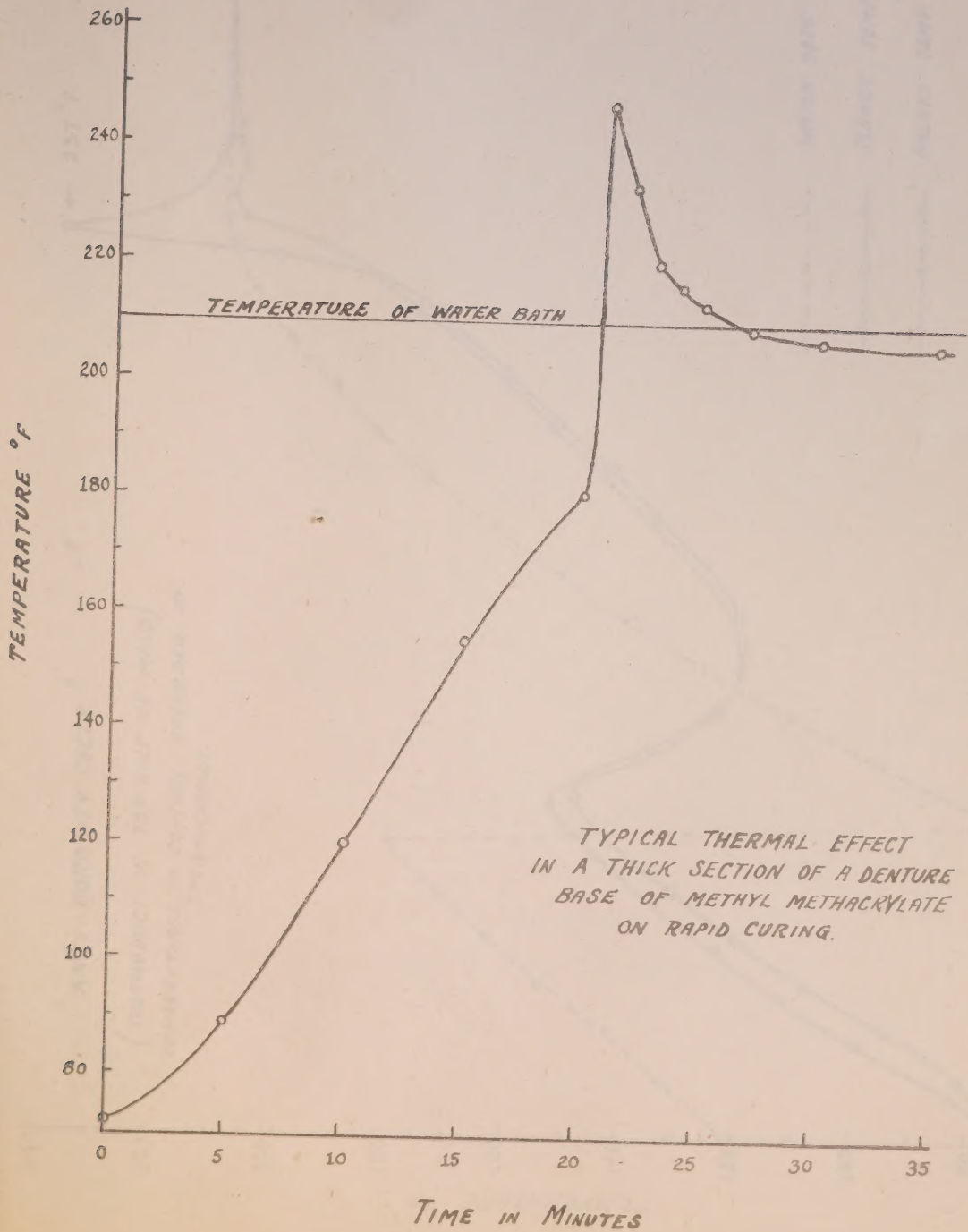
Plastic cured by this cycle meets the requirements of the transverse strength test and dentures made by this treatment show good dimensional stability after immersion in water at body temperature (99°F.) for several months.

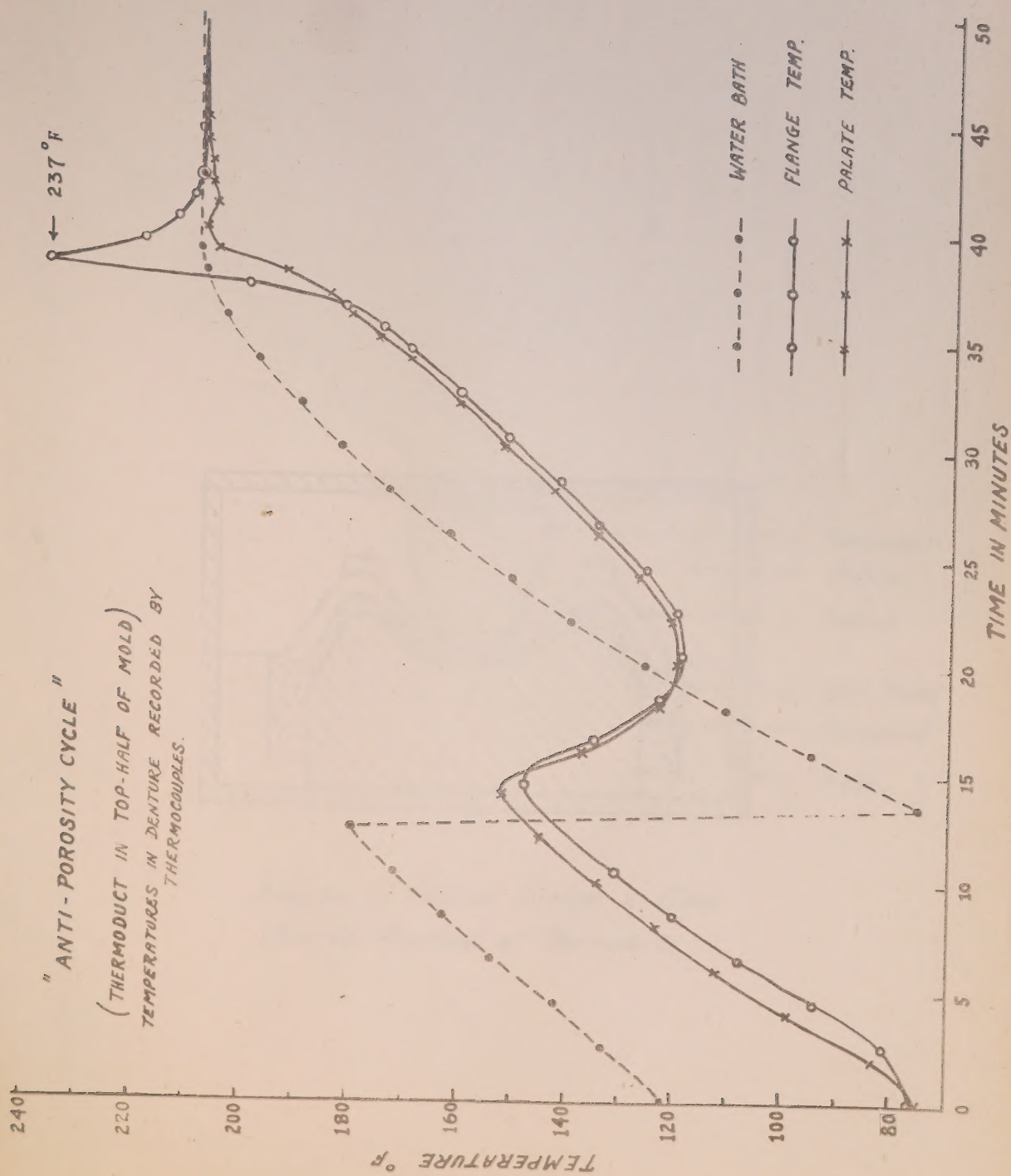
We believe that by using the methods described in this report a very satisfactory denture can be produced.

Separating Medium

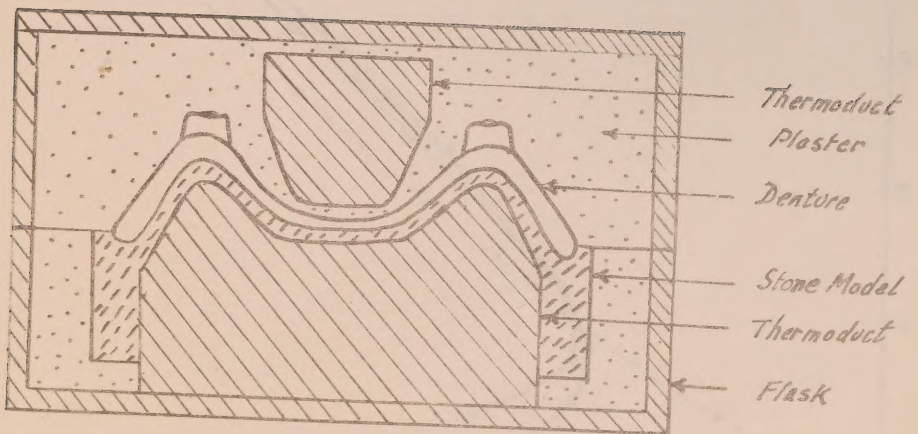
In addition to the work done on methyl methacrylate, we have investigated the use of a separating medium of cellulose triacetate and ethyl silicate (See Report No. 4609) which, if properly used, gives a smooth mold surface and should reduce the work of grinding and polishing. Briefly, it consists of painting the mold surfaces, except the teeth, with a 3 per cent solution of cellulose triacetate in chloroform and alcohol, allowing the surfaces to dry thoroughly and then painting again with a solution of ethyl silicate. We believe it has possibilities but we hesitate to advocate its general use until the dental profession has tried it and passed judgment on its suitability.

October 17, 1946.

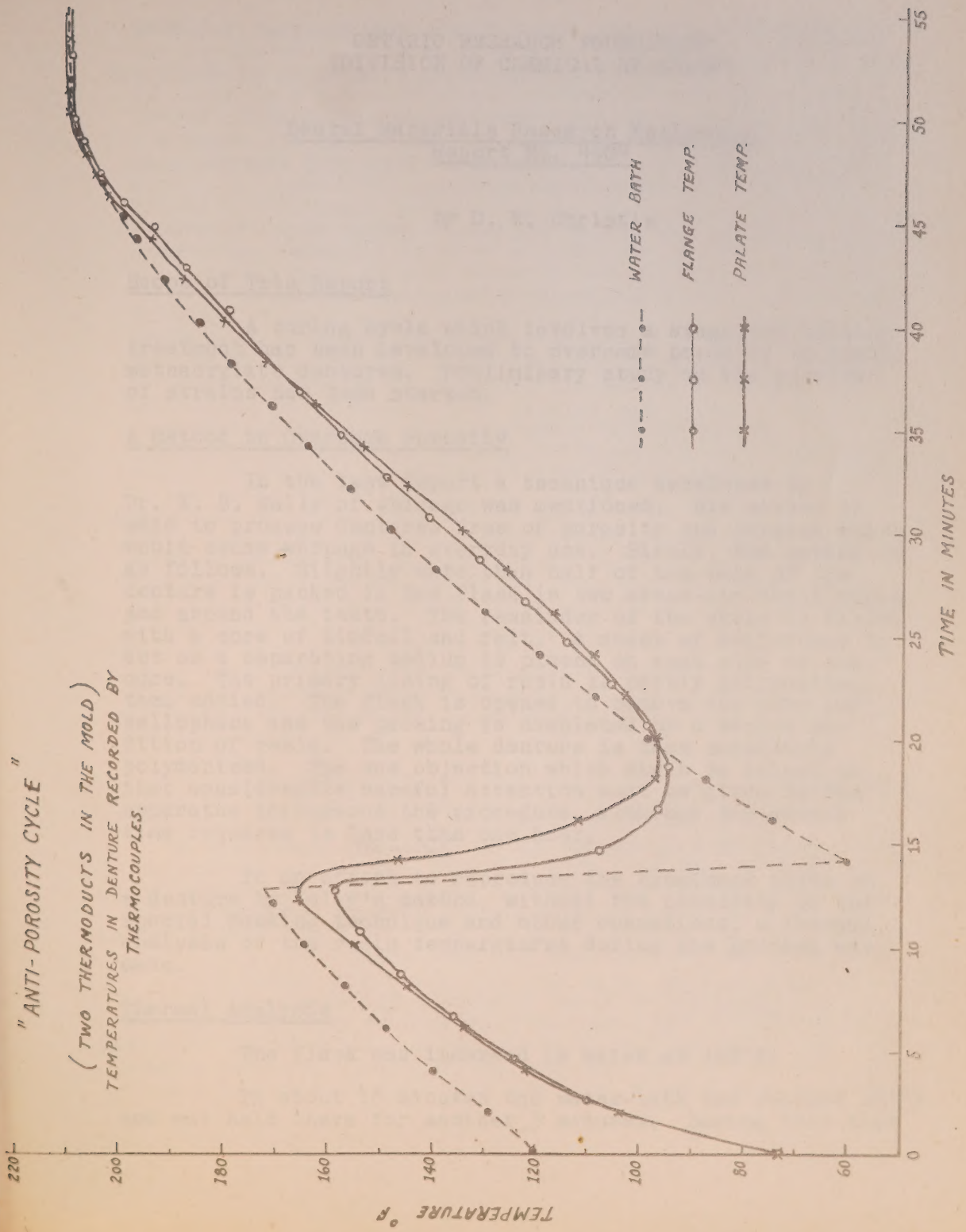




"App. E"



*Diagram of Section through a Flask
showing Positions of Thermoducts*



APPENDIX "F"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4304

by D. R. Christie

Scope of This Report

A curing cycle which involves a staggered heating treatment has been developed to overcome porosity in methyl methacrylate dentures. Preliminary study on the problem of strains has been started.

A Method to Overcome Porosity

In the last report a technique developed by Dr. E. B. Kelly of Chicago was mentioned. His method is said to produce dentures free of porosity and strains which would cause warpage in everyday use. Simply, the method is as follows. Slightly more than half of the bulk of the denture is packed in the flask in two areas--in the flanges and around the teeth. The remainder of the space is filled with a core of tinfoil and felt. A sheet of cellophane to act as a separating medium is placed on each side of the core. The primary lining of resin is partly polymerized, then cooled. The flask is opened to remove the core and cellophane and the packing is completed by a second addition of resin. The whole denture is then completely polymerized. The one objection which might be raised is that considerable careful attention must be given to the apparatus throughout the procedure, although the actual time required is less than one hour.

In an effort to reproduce the treatment given to a denture by Kelly's method, without the necessity of the special packing technique and other operations, a thermal analysis of the resin temperatures during the process was made.

Thermal Analysis

The flask was immersed in water at 120°F.

In about 15 minutes the water-bath had reached 185°F. and was held there for another 3 minutes. During this time

the temperature in the ridge of the denture rose to 180°F.

The flask was plunged into cold water at 60°F. for 1 minute and then allowed to bench-cool for 4 minutes. At the end of this time the resin temperature fell to 125°F. The flask was opened, packing of the second and final amount of resin was completed and processing started again as soon as this was accomplished.

The flask was again put in water at 120°F. and heated to 200° F. in about 12 minutes and then was held there. The time at 200° F. need only be long enough to assure that the resin reaches this temperature.

In 12 minutes, the resin was at 178°F. In 16 minutes it reached 200°F. and rose to 205°F. in 18 minutes, falling gradually back to 200°F. in 10 more minutes.

Reviewing the time-temperature relations of the polymerization curves presented in previous reports, two possible curing cycles were investigated.

The first of these cycles made use of a water-bath at 212°F. while the second used a more moderate heat treatment starting at 120°F., the object of each being to cause partial polymerization of the resin, followed by cooling and then a second heating stage to complete the cure.

In each method, it was necessary to find the times required to carry out successfully each stage of the curing cycle. A sheet of cellophane was placed between the resin and the model to permit opening of the flask for inspection at any time.

Results

In the boiling water-bath method, the first trials were unsuccessful because the preliminary immersions of the flask in the bath were too long and polymerization of the resin had advanced too far. In these cases it was found that the ridges and flanges of the denture were hard and porous and the palate was still soft. Further curing failed to remove the bubbles from the hard areas.

The time of flask immersion to cause partial polymerization was progressively reduced from 12 minutes for the first trial to 5 minutes for a fifth trial. Porosity was also reduced in each successive trial, but when other areas of the denture were entirely free of porosity, the

"F-3"

palate invariably had some. Palatal porosity is probably the result of the position of this part of the denture near the centre of a poor heat-conducting medium.

The difficulties with the boiling water-bath method are obvious. The correct time for the initial polymerization is short and difficult to estimate, but at the same time should be known with considerable certainty. Also, the ridges and flanges, being close to the outside of the flask, are heated more rapidly than the palate and therefore would polymerize sooner.

A slower reaction is desirable for several reasons. It would allow greater flexibility in heating times without the danger of causing too great a degree of polymerization for the initial stage, especially in the ridge and flanges. It would lessen the temperature differential between the palate and other areas, thus keeping all parts of the denture at approximately the same degree of polymerization and tending to reduce internal strains. It would also allow polymerization to proceed slowly and avoid sudden exothermic reactions in the early stages which might cause porosity.

In any process using a plaster investment, the palate temperature will lag behind that of other parts because of its central position in a poor heat conductor. In order to keep all parts of the resin at about the same temperature, the use of a thermoduct seems logical.

In the more moderate heat treatment starting at 120°F. some success was achieved. It was only when a thermoduct was used in the investment that a non-porous denture could be obtained.

The following heat treatment has been employed many times to produce dentures entirely free of porosity.

Immerse the flask in the water-bath at 120°F.

Apply a good flame to raise the temperature of the bath to 180°F. in 12 to 15 minutes, ie. 4°F. to 5°F. per minute,

Remove the flask from the bath, replace the hot water with cold tap water (50°F. to 60°F. is satisfactory) (or put the flask in another bath) and heat to boiling in 25 to 30 minutes. Allow the flask to remain in the boiling water for at least 10 minutes.

These figures may vary depending on the size of the flask, or how completely the denture fills it but they are probably flexible enough to allow for these differences. In addition, this procedure requires a minimum of attention to the apparatus for this kind of staggered heat control and can be done in one hour or less.

We have recorded the temperatures attained in the palate and ridge of a clear denture without teeth and submit a graph of a typical result. It will be noticed that, in our case, the temperature of these two parts of the denture were nearly the same throughout the process. Evidence of rapid polymerization is shown by the peak in the ridge curve and a somewhat smaller increase in temperature in the palate at approximately the same time. These sudden temperature increments do not cause porosity in any way and this is so probably because the whole mass of the resin has become considerably polymerized before the rapid rise in temperature occurs.

However, the dentures we have made are probably as thick or thicker than most commercial dentures. The thicknesses of the palate and the ridge where the thermocouples were placed were $1/8$ inch and $1/4$ inch respectively. The ordinary denture may be appreciably thinner in these areas and when teeth are included in the ridge, the bulk of resin there is still further reduced. This would mean that temperature peaks due to rapid polymerization would be even less than in the case depicted by the graph.

Strains

Each denture, as it was processed, was examined in polarized light for strains. Models were poured immediately after curing in several polished dentures and the dentures themselves placed in water at room temperature (about 77°F.) to be used later to observe any changes in adaptation to the models.

One denture with a prominent strain pattern was immersed in hot water for 5-minute periods at temperature intervals up to 212°F. After it was allowed to cool, it was placed on its model to observe any changes in fit.

"F-5"

<u>Temperature</u>	<u>Effect on Denture</u>
40°C. - 104°F.	No change
50°C. - 122°F.	" "
60°C. - 140°F.	" "
70°C. - 158°F.	" "
80°C. - 176°F.	Strains slightly decreased but adaptation to model good
90°C. - 194°F.	No strains apparent; slight change in fit.
100°C. - 212°F.	Considerable warpage.

At 176°F. the strain pattern was disappearing. At 194°F. there were no strains visible but the adaptation to the model was still good. Heating at higher temperatures caused further considerable warpage.

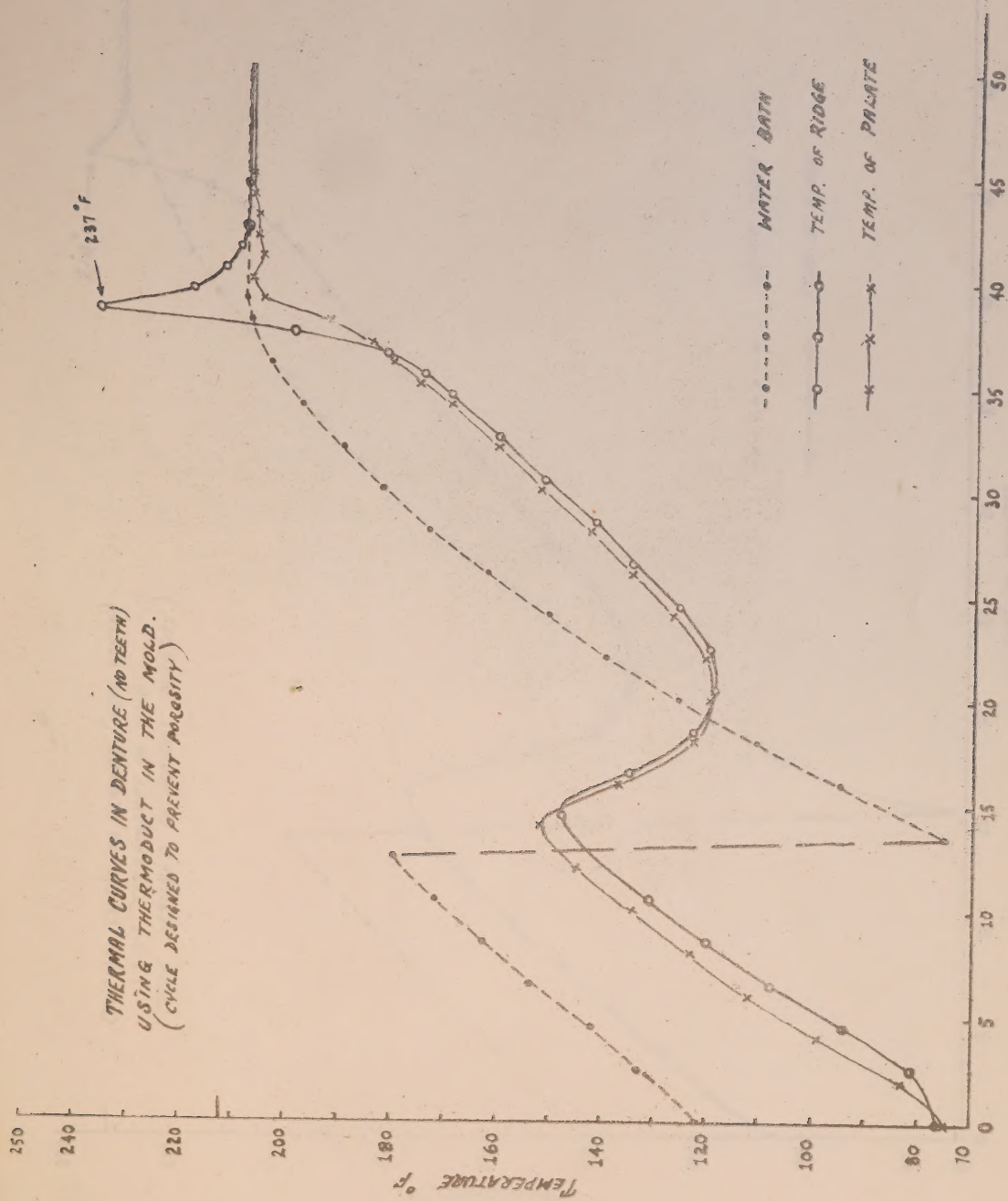
We have not dealt with the strain problem greatly to date but we propose to follow this study in the near future, and, if possible, to make a permanent record of the strains and their changes by means of photographs.

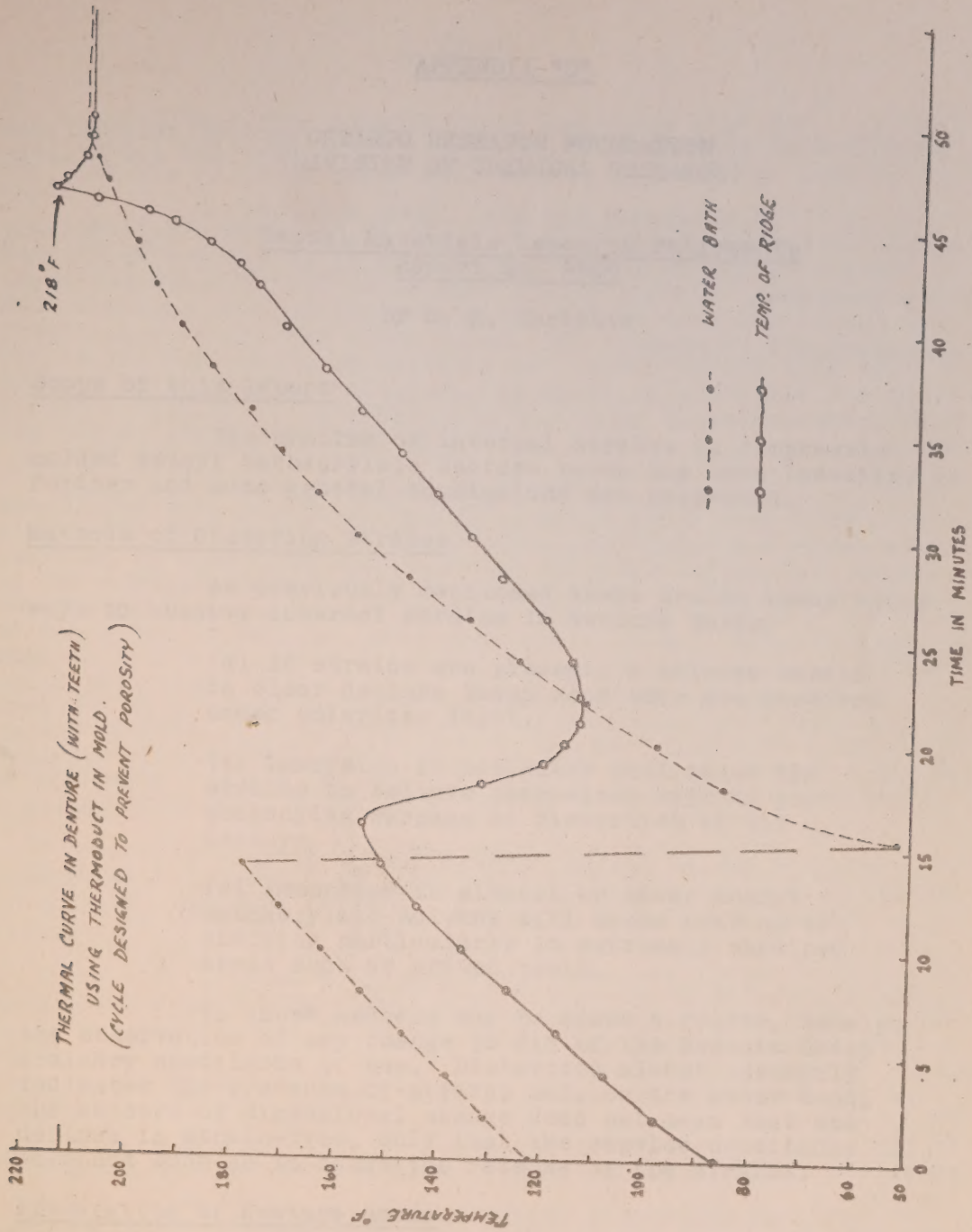
We can say, in general, that strain patterns were less prominent in dentures which were processed entirely under total spring-clamp pressure and which were subsequently cooled very slowly, but when a clear denture was made in this manner with porcelain teeth an intense strain pattern was visible around the teeth.

TORONTO, Ontario.

April 8, 1946

THERMAL CURVES IN DENTURE (NO TEETH)
 USING THERMOCLUST IN THE MOLD.
 (CYCLE DESIGNED TO PREVENT POROSITY)





THERMAL CURVE IN DENTURE (WITH TEETH)
 USING THERMOCOUPLER IN MOLD.
 (CYCLE DESIGNED TO PREVENT POROSITY)

APPENDIX "G"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4605

by D. R. Christie

Scope of this Report

The problem of internal strains in compression molded methyl methacrylate denture bases has been investigated further and some general conclusions are presented.

Methods of Observing Strains

As previously mentioned there are at least three ways to observe internal strains in denture bases.

(a) If strains are present, a colored strain in clear denture bases when they are observed under polarized light.

(b) Immersion in hot water will cause the strains to relieve themselves with an accompanying warpage or distortion of the denture.

(c) Immersion in alcohol or other methyl methacrylate solvent will cause crazing or checking particularly in extremely strained areas such as around teeth.

To these methods may be added a fourth, namely, the observation of any change in fit of the denture under ordinary conditions of use. Distortion almost certainly indicates the presence of strains but, on the other hand, the absence of dimensional change does not mean that the denture is strain-free, only that the service conditions were not such as to cause the release of the strains.

Preparation of Denture Bases

In the previous report a curing cycle was described which is intended to prevent porosity. This procedure involves partial polymerization of the resin, cooling and then further heating to effect a complete cure. Specifically, after the mold was packed and the resin compressed, the flask was immersed in water at 120°F. and heated to 175° F. in approximately 15

minutes. The bath water was replaced with cold tap water and heated to boiling in from 25 to 30 minutes. The flask was allowed to remain in the boiling water about 15 minutes.

Some dentures were cooled by allowing the flask to remain in the hot bath until the temperature had dropped to 140°F. Others were cooled quickly by immersing the flask in cold water.

Examination for Strains

All dentures, after polishing, were examined for strains in polarized light and artificial stone models were made of their bearing surfaces. Some dentures were placed in water at room temperature to be used for observation of any changes in adaptation to their models, while others were scratched with fine gauze marks on flanges and ridges and subjected to hot water immersion tests, by placing the unsupported denture in water for 5-minute intervals, cooling and then measuring with vernier calipers.

Results

Several dentures which were made from six weeks to two months ago have been kept in water at room temperature since they were made. These dentures have varying degrees of strain when viewed in polarized light but without exception they maintain an excellent fit on their respective models.

This result indicates that, at room temperature, as long as dentures are kept wet there is no danger of warpage occurring because of the release of internal strains. Hot water immersion relieves internal strains in dentures at relatively high temperatures. Some dentures for these tests were cooled slowly and others quickly and some were made with tinfoil on one side only while others were made with sodium silicate solution as a separating medium on both sides. Table I shows the results.

It will be seen that with average dentures little or no effect is produced up to temperatures of 90°C. (194°F.). In fact, the adaptation to the model of some dentures is excellent after 5 minutes immersion at 90°C.

Denture No. 5 showed very considerable warpage at 90°C. but had retained a good fit at 85°C. This denture was deliberately made very thin and could be easily bent in one hand. The point to note in this case is that even a thin denture will withstand hot water up to 85°C. but beyond that

considerable warpage occurs, even though no appreciable strain pattern was visible in polarized light.

In waxing a model, the wax should be built up no thicker than necessary and large bulks of resin should be avoided because of the danger of producing porosity and also because thick dentures are apt to be more highly strained than thin ones. When dentures warp on hot immersion, the flanges and ridges move toward each other. In other words, the release of the strains causes the denture to be "pinched in" laterally and then the denture will not fit exactly on its model. The denture can be forced to the model, however, but of course it springs back to its former shape when removed.

Several dentures were pressed in this way to their models and then heated above 90°C., after which they were allowed to cool before being removed. Some of the warpage was overcome by this treatment although not completely. This suggested the pressure technique which was applied to dentures 6, 7 and 8. The luxene spring compress used in processing exerted a pressure of about 350 lb./sq. in. when completely closed. Slightly more than half this pressure was used throughout the cycle until the water bath began to boil, then the full pressure was applied. However, this technique does not seem to have any particular merits as far as Table I indicates, although dentures 6 and 7, prepared in this way with tinfoil on one side and sodium silicate on the other, showed an expansion across the ridge rather than a contraction which occurred in all other instances.

No appreciably different effect on the dimensional changes was caused by the variations in technique such as method of cooling, variable pressure or use of tinfoil and sodium silicate.

Internal strains do not seem to be serious defects unless the dentures are subjected to hot water above 85°C. (185°F). It is improbable that any person can drink liquids as hot as 185°F., or hold them in his mouth for a time long enough to damage a denture. Those who wear dentures should be cautioned not to wash them in hot water.

Strains in Dentures with Teeth

Two dentures were prepared with clear Lucitone, one with porcelain teeth and one with plastic teeth. The one with porcelain teeth showed an intense strain pattern around the teeth in polarized light while the other showed very little strain.

Experimental color photographs were taken of the denture with porcelain teeth but the processed transparencies have not been received to date.

Future Work

The subject of strains will always arise as long as work is being done and the phase presented here still requires a permanent visual record, that is, photographs.

From time to time as new literature comes to our attention the problem of shrinkage is mentioned. We shall continue investigations in this field if the matter seems urgent.

We do not feel that we have rounded out the study of the use of metal powder in the investing plaster and propose to continue with this subject.

We have not yet investigated a method of polishing dentures by the use of solvent vapors. When a satisfactory molding technique has been worked out, the effect of polishing on moisture absorption might be studied.

May 10, 1946.

TABLE I

Decrease in Dimension (%)

No.	Cooling	90°C.			95°C.			100°C.			Adaptation to Model	Remarks
		Flange Ridge	Flange Ridge	Flange Ridge	Flange Ridge	Flange Ridge	Flange Ridge	90°C.	95°C.	100°C.		
1	Rapid	0.28	Negl.	0.78	0.33	0.93	0.97	Sl.w.	c.w.	c. w.	Tin foil on one side	
2	Flasked Opened at 100°C.	0.1	0.1	0.63	0.71	1.2	0.89	Good	c.w.	c. w.	" "	
3	Slow	Negl.	Negl.	--	--	1.54	1.33	Excellent	--	c. w.	Silicate on both sides	
4	Slow	Negl.	Negl.	--	--	.89	1.2	Excellent	--	c. w.	Silicate on both sides	
5*	Slow	1.45	2.2	2.1	2.9	--	--	c. w.	c. w.	--		
6**	Slow	0.49	+0.39	0.94	+0.22	1.63	+0.50	Excellent	Sl.w.	c. w.	Tin foil on one side	
7**	Slow	0.16	+0.43	0.97	+0.11	1.77	+0.16	Sl.w.	c. w.	c. w.	" "	
8**	Slow	0.16	0.44	0.32	0.33	0.69	0.72	Good	Sl. w.	c. w.	Silicate on both sides	

Sl. w. = slight warpage

c. w. = considerable warpage

* = very thin denture - excellent fit at 85°C.

** = variable pressure

APPENDIX "H"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4606

by D. R. Christie

This report is necessarily brief because at this time we have no new significant data to present. Some experimental work on the proper cure-time and corresponding work on internal strains was begun but was interrupted by our decision to acquire and use some special apparatus which should be ready very soon.

It is our belief that a great source of trouble in processing satisfactory dentures, particularly in regard to internal strains, is the inability to control the temperature of the resin and avoid temperature peaks or gradients as the exothermic polymerization reaction proceeds. If these localized temperature differences can be prevented, so that all parts of the denture polymerize at the same rate and to the same degree, we feel that many difficulties will be overcome and the quality of the dentures greatly improved.

Many of our previous studies have been devoted to this problem of temperature control and, to some extent, we have been successful. In this regard, we call attention again to the heating technique presented in Report No. 4604 which eliminates porosity and controls the resin temperature to a large degree.

In our future work, we will attempt to prevent any thermal gradients during the course of the polymerization by the use of a specially designed thermoduct which is to fit the denture model from the lower side. This thermoduct will be placed in close proximity to the bearing surface of the denture and will be directly in contact with the outside flask. With this and the thermoduct which is also used in the tooth-half of the investment, we hope to eliminate thermal inequalities as a potential source of trouble.

Another topic of interest is the possibility of eliminating trial-packing by using the correct amount of resin mixture on the first flask closure. This amount could be calculated by knowing the ratio between the weight of resin used to pack the mold and the weight of the wax used in modelling the denture. If such a procedure can

"H-2"

be worked out, it would be a saving on time and material and would be of particular value in dental laboratories where considerable work is done.

At present then, we are about to start a new series of thermal investigations on the outcome of which will depend several problems such as internal strains and warpage. In this connection, we also intend to determine how long it is necessary to continue the processing of a denture once it has reached a temperature of 212°F. When we have developed the best possible technique, we will be in a position to investigate a solvent-vapor polishing method.

June 7, 1946.

APPENDIX "I"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4607

BY D. R. Christie

Scope of this Report

An analysis of the curing temperatures attained in a denture when a thermoduct is used in the model half of a standard compression molding flask is presented and a series of experiments on dentures to study the effect of curing time on warpage caused by hot water immersion is described.

Use of a Thermoduct in the Model

A large bronze thermoduct was made and shaped similarly to the artificial stone models which are used in making the dentures. When this thermoduct is placed in the unset stone, there is approximately one-eighth inch of stone between the thermoduct and the bearing surface of the model at all points. The base of the thermoduct was polished to a smooth surface to fit the bottom of the flask and to give good contact for thermal conduction.

A diagram accompanying this report shows a section through a dental flask and the positions of the thermoduct and invested denture.

The purpose of the thermoduct is to control the temperature of the curing resin and thereby avoid sudden peak temperatures and temperature differentials in the various parts of the denture.

These peaks and differentials are possible sources of strain since they may cause differences in degree of polymerization throughout the resin. If so, the finished dentures would be more apt to warp and undergo distortion under service conditions.

Thermal Analysis

Dentures were invested as shown in the diagram. A thermocouple was fixed in the flange immediately behind the molars and another was placed in the thinner resin of the palate.

After packing, the flask was immersed in a water bath at 120°F. and heated to about 170°F. over a period of 10 to 20 minutes. This time is not critical so 15 minutes is a good average.

When the bath reaches 170°F., the flask is removed, the water changed with cold tap water and the flask re-immersed for further heating. The bath is allowed to come to a boil in about 30 minutes. Again, this time appears not to be critical insofar as porosity is concerned and may be shorter or longer.

During this heating cycle which was designed specifically to avoid porosity, the temperature of the bath was recorded as well as readings from the thermocouples, inserted in the resin. The analysis was repeated several times to check and a typical result is shown on an accompanying graph.

It will be noted that no temperature peaks occurred and the temperatures of the resin in the flange and in the palate were approximately the same throughout the curing cycle. Thus the thermocouple in the stone model accomplishes its purpose.

Dentures were allowed to remain in the boiling water bath for different time intervals. The results of this treatment will be discussed later. At the end of the cure, they were allowed to cool in the bath to 150°F. and then removed from the flask.

Shrinkage

An impression of the occlusal surface of the teeth in each waxed-up denture model was made before pouring the tooth-half of the investing plaster.

When the dentures were removed from the flask after polymerization, the occlusal surfaces and the bearing surfaces were slightly off from a good fit. Part of this distortion may be caused by polymerization shrinkage. To avoid this, it is necessary to pack a slight excess of resin in the mold. According to some, when this is done, there is the danger of causing an "open bite" by the formation of a heavy flash between the halves of the flask. However, if one or a few small channels are cut in the plaster and the rim of the flask from the denture to the outside, flashes may form without forcing the halves apart.

Even when this precaution is taken to avoid polymerization shrinkage, some distortion will be present as a result of the difference in the thermal contractions of the investment material and the resin.

However, the dentures showed excellent adaptation to their models after at least two days immersion in water and being brought to body temperature of 99°F. The change in dimensions caused by water absorption and the expansion due to the difference between room and body temperatures is enough to compensate for thermal distortion.

Strains

Clear, finished dentures were examined in polarized light and the only strain patterns visible were those around the porcelain teeth. These strains can be removed by heating the dentures in water, but they reappear when the resin and the teeth cool again. Once more, this effect is caused by a difference in the coefficients of thermal expansion or contraction of the porcelain and the methyl methacrylate.

Hot Water Immersion Tests for Strains

A series of dentures was made using the heating cycle described previously. At this writing, two dentures were made under each of the following conditions:

- (a) 2 minutes at 212°F.
- (b) 15 minutes at 212°F.
- (c) 30 minutes at 212°F.

and then cooled to 150°F. before removal from the flask.

These dentures were then subjected to hot water immersion at temperatures of 185°F., 194°F. 203°F. and 208°F. for 5-minute intervals, the purpose of the tests being to learn if the different curing times had any effect on the distortions or warpages caused by these temperatures.

Before the tests, small gauge marks were placed on the flanges and on the ridges immediately behind the molars and the distances measured with vernier calipers. A table shows the linear percentage change in these dimensions after the tests.

Percentage Change in Dimensions on Hot-Water Immersion
After Different Curing Intervals at 212°F.

	2 min. at 212°F.			15 min. at 212°F.			30 min. at 212°F.		
	<u>Flange</u>	<u>Ridge</u>	<u>Fit</u>	<u>Flange</u>	<u>Ridge</u>	<u>Fit</u>	<u>Flange</u>	<u>Ridge</u>	<u>Fit</u>
After 185°F.	0.2	0.2	G	0.0	---	G	0.0	0.2	G
" 194°F.	0.2	0.4	SW	0.2	---	G	0.2	0.5	SW
" 203°F.	1.2	1.3	CW	0.4	---	CW	1.3	1.5	CW
" 208°F.	1.4	1.4	CW	1.6	---	CW	2.1	2.5	CW
" 185°F.	0.2	0.3	G	0.2	0.2	G	0.2	0.2	G
" 194°F.	0.2	0.8	SW	0.5	0.6	SW	0.2	0.4	SW
" 203°F.	0.7	2.8	CW	1.5	1.8	CW	1.1	1.2	CW
" 208°F.	1.7	3.0	CW	1.7	2.6	CW	1.5	2.1	CW

G = Good

SW = Slight warpage

CW = Considerable warpage

These tests show that some residual strain still exists in all the dentures and that they were impossible to remove by allowing the dentures to cool slowly or anneal in the bath. At 185°F. only a slight change is produced which has little effect on the fit of the dentures on their models. Above this temperature though, they undergo considerable linear change, enough to make them useless. There seems to be no great difference in the final results produced by the various curing intervals, but the transverse strengths of the resins would have to be determined on test pieces. In addition, dentures should be tested for warpage at body temperature over a period of several months, to make certain that no distortion will occur.

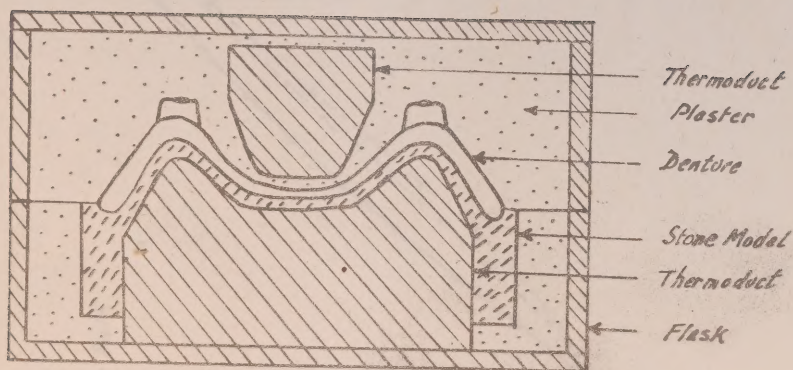
Future work

1. Prepare test pieces for transverse strength tests after cures at different intervals at 212°F.
2. Prepare dentures for various curing intervals to be tested for distortion at body temperature over a long period of time.
3. Solvent Vapor Polishing Method

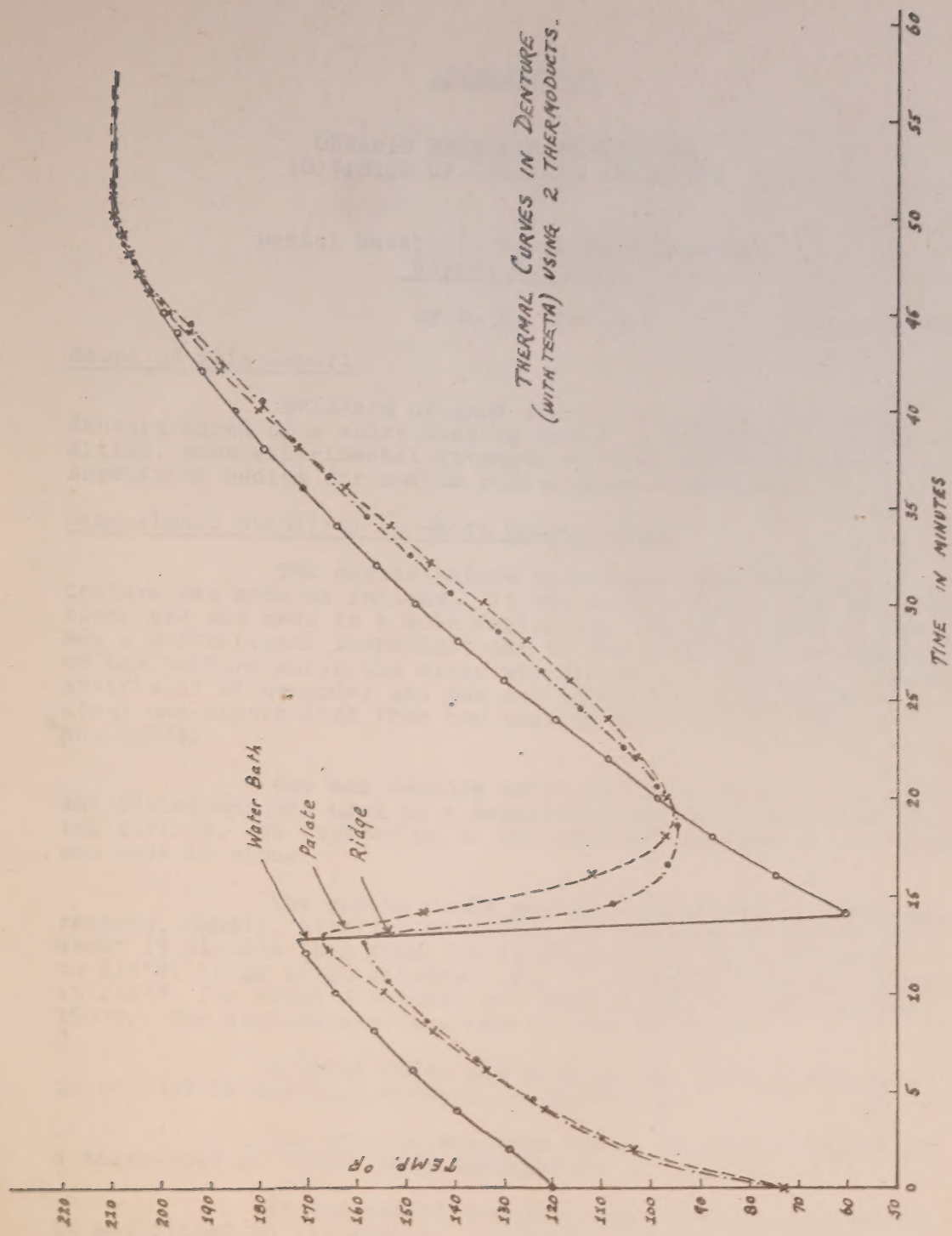
Investigate the possibility of polishing dentures by the use of the vapors of a solvent for the denture base material.

4. In a recent British Dental Journal the use of a "silicon ester" as a separating medium was suggested. Some ethyl silicate has been obtained and perhaps can be used in place of sodium silicate which we feel has some unsatisfactory features attending its use.

June 10, 1946.



*Diagram of Section through a Flask
showing Positions of Thermocouples*



APPENDIX "J"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4608

by D. R. Christie

Scope of This Report

Evidence of good dimensional stability in a denture cured by a short heating cycle is presented. In addition, some experimental attempts to find a substitute separating medium for sodium silicate are described.

Dimensional Stability in Short Curing Cycle

Two months before this report was written, a denture was made as follows. It was a full upper with porcelain teeth and was made in a mold containing two thermoducts. One was a conventional thermoduct set in the investment in the arch of the denture while the other was shaped approximately like the artificial stone model and was set into it to a distance of about one-eighth inch from the bearing surface (See Report No. 4607).

The wax denture model was tin-foiled on one side and cellophane was used as a separating medium against the bearing surface. An impression of the occlusal surface of the teeth was made in stone.

The curing cycle was that described in previous reports, namely, starting at 120°F. and heating to 175°F. in about 15 minutes then from the temperature of cold tap water to 212°F. in 20 to 25 minutes. The flask was allowed to remain at 212°F. for about 2 minutes and then cooled in the bath to 150°F. The denture was then removed and polished.

A stone model was made of the bearing surface to be used in checking dimensional stability.

The denture was then put in water and placed in a thermostat at 99°F., body temperature.

At the end of one month and again in two months it was placed on its models. At 99°F., it was an excellent fit on each model.

This experiment shows good dimensional stability in this denture. A longer period under these conditions is necessary before a final statement can be made but any change in the denture's dimensions would be surprising. Furthermore, the above-mentioned curing cycle will be established as satisfactory only when the resin is subjected to and passes an A. S.T.M. test for transverse strength.

Separating Medium

Many separating media have been used in the making of dentures. None have been completely satisfactory. Tinfoil on both sides of a denture is much used but in using foil it is difficult or almost impossible to remove wrinkles which are subsequently transferred to the denture and must then be ground off. The Canadian Dental Corps used a combination of tinfoil and sodium silicate, the latter on the model side. Sodium silicate is not satisfactory because it forms a white crust or deposit on the denture which is difficult to remove. If a good separating medium can be found, its application to both sides of an investment-mold would produce dentures with smooth surfaces and would eliminate time-consuming grinding and polishing. In the British Dental Journal (October 1945) a "silicon ester" was claimed to be a good separating medium. This material was probably ethyl silicate and samples were obtained by us for testing.

Ethyl Silicate

Ethyl silicate, $\text{Si}(\text{OC}_2\text{H}_5)_4$, is hydrolyzed, in the presence of a coupling agent such as ethyl alcohol, to silicic acid which loses water to deposit silica.

Ethyl silicate is widely used as an investment bonding material for special molds which must withstand high temperatures such as in the casting of steel and high-melting alloys. Its use in bonding denture investments is impractical from the cost standpoint and therefore must be confined to the making of surface coats only.

Plaster and artificial stone investments, being porous, absorb large quantities of ethyl silicate solutions. Some means must be found to reduce absorption.

If the investment is first saturated with water to lessen absorption, the silica films crack in a short time.

One artificial stone model was made with the following composition ratio:

artificial stone (Coecal) -	6 gms.
water -	2 gms.
ethyl silicate solution -	1 cc.

After this mix had set, it still had a strong tendency to absorb. It was therefore soaked in water for a few minutes, and then brushed with more ethyl silicate solution. This time very little absorption occurred and a smooth, glossy surface was obtained. It did not crack after six hours standing, so a denture was made from it.

The silica surface stood up under the steps of waxing, investing, boiling out the wax and curing and the denture came away cleanly from the model with a good smooth bearing surface.

It was extremely difficult to duplicate these conditions to obtain a smooth film, uneven absorption and cracking of the surface occurring almost invariably.

Other methods were attempted to prevent absorption of the ethyl silicate.

(a) Sodium silicate and calcium chloride react to precipitate calcium silicate which is water insoluble. It was hoped that by precipitating the calcium silicate in situ, the pores of the investment would be filled and a primary surface would be formed, over which ethyl silicate could be applied. Various concentrations of calcium chloride solutions were tried with a sodium silicate solution (1 part in 10) but many variations in treatment, including application to hot and cold models, drying in an oven, brushing and dipping, were unsuccessful. Some films were excellent in part but even these tended to crack in a short time.

(b) Water solutions of sodium carboxymethylcellulose (SCMC) and aluminum carboxymethylcellulose (ACMC) dry to produce smooth films, SCMC giving a water-soluble one and ACMC a water-insoluble film. Artificial stone models were impregnated with one or the other of these solutions, using approximately 2% concentrations, dried, and then coated with ethyl silicate. Absorption was decreased, not eliminated, and the silica surfaces cracked badly.

(c) A surface of wax on the investment should prevent absorption. Ethyl silicate can be brushed on to a wax surface. The requirements of a wax for this purpose are

(1) a melting point higher than 212°F. or maximum curing temperature.

(2) solubility in a solvent boiling below 212°F. so that vapors can be easily removed.

A wax, known here as Zeco No. 679, has these requirements. It is a hard, white wax melting about 240°F. and is slightly soluble in hot benzene, chloroform and carbon tetrachloride. Without a solvent it obviously cannot be smoothly brushed on a model at a temperature below its melting point and an emulsion cannot be easily prepared.

Some success was achieved by brushing a chloroform solution of this wax to a hot model but completely satisfactory results were not obtained and only a few trials were made.

(d) A Saran latex, which is a polyvinylidene chloride emulsion, can be easily applied to the investment surfaces to give very smooth, glossy films. A sample which we have is known as F-122, A-20 with 56% solids content. It contains 20%, based on the weight of solids, of dibutyl phosphate as a plasticizer. Now dibutyl phosphate is also a plasticizer for methyl methacrylate and its use is not advisable. However, even if the strength of denture was not affected by its use, the presence of the plasticizer probably is the cause of the films being sealed to the denture during polymerization. The films can be scraped off but some discoloration of the resins also occurs. The use of Saran latex has consequently been abandoned.

We have recently seen a reference to the use of ethyl silicate solutions containing an inert filler, such as powdered quartz, for the production of smooth surfaces on porous materials. At this writing, we have not had a chance to investigate this application but it warrants immediate study.

Future Work

1. The study of ethyl silicate solutions, containing an inert filler, as a suitable separating medium.

2. The preparation of test pieces of methyl methacrylate resin for the purpose of determining transverse strengths under conditions

(a) similar to those in the curing cycle described in this report and

(b) similar to those described in this report with prolonged heating at 212°F. to learn if an extended cure is necessary.

3. Possible investigation of the use and properties of Luxene 44.

4. The investigation of new plastics suitable for making denture bases.

September 10, 1946.

APPENDIX "K"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4609

by D.R. Christie

Scope of this Report

The full upper denture made almost three months ago and described in the last report continues to show good dimensional stability. Some remarks on solvent vapor polishing are included. Cellulose triacetate offers good possibilities as a separating medium. Transverse strength tests have been made on test pieces cured by different techniques.

In this report, the following cure will be called the "anti-porosity cycle". The dental flask is immersed in the water bath at 120°F. The temperature of the bath is raised to about 175°F. in 10 to 15 minutes. Then the water is changed with cold tap water and heated over the same flame to 212°F. in from 25 to 30 minutes.

Dimensional Stability

A full upper denture was made nearly three months ago by the "anti-porosity cycle". (See Report No. 4608) An impression of the occlusal surfaces of the teeth was made from the wax model of this denture and after removal from the flask an impression was also made of the bearing surface. The denture was polished, immersed in water and placed in an oven at 99°F. (body temperature).

When this denture is removed from the water and immediately tried on its models, it shows excellent adaptation and no signs of dimensional change.

Solvent Vapor Polishing

A few attempts have been made to polish dentures by the use of solvent vapors. In particular, ethyl acetate was used by simply heating a container and allowing a narrow stream of its vapors to flow against an unpolished denture surface. The result, as found here, was extensive crazing

of the entire denture surfaces and particularly around the teeth. When plastic teeth are used, they will also be crazed. This effect is not surprising, for as indicated in Report No. 4605, immersion of dentures in solvents is one method of revealing strains. It seems advisable to keep solvents, in any state away from a cured denture.

Separating Medium

It would be desirable to use a separating medium which would impart a smooth surface to the denture base material. Tinfoil preserves the clarity of plastic surfaces but it is extremely difficult to remove wrinkles from it, and of course the imperfections caused by these wrinkles must be ground off. It has been our aim in this investigation to find a separating medium which can be easily applied to the mold surfaces, which will preserve the clarity of the plastic surface and which will impart a surface free of imperfections so that very little, if any, grinding will be required and the denture can be finished by buffing or polishing alone.

Cellulose triacetate shows promise of meeting these requirements. Cellulose triacetate with a solution of ethyl silicate applied on top of it is better.

For this purpose, we have used Hercules brand cellulose acetate TH-2, which is a high viscosity cellulose triacetate, made up to a 3 per cent solution in an 80:20 mixture by volume of chloroform:ethyl alcohol. This solution is low enough in viscosity that it can easily be brushed on to the mold surfaces.

The ethyl silicate solution has this composition:

- 60 vol. - tetraethyl orthosilicate*
- 32 vol. - ethyl alcohol (absolute or 190-proof)
- 8 vol. - dilute HCl (0.3 to 5.0% in water)

It should be allowed to stand 8 to 12 hours before use but must be used before it sets to a gel. If the container is kept covered, gelling will not occur for several weeks.

* Supplied by Carbide and Carbon Chemicals Corporation

Application

After the wax has been boiled out of the denture mold and the flask has become cool and dry, the cellulose triacetate solution is brushed on the mold surfaces, except on the teeth, until a smooth surface is obtained. Some absorption of the solution will occur and several applications may be required. This film must now be allowed to dry thoroughly. An easy method is to place the flask halves in an oven at 150°F. or thereabouts for 15 or 20 minutes. A longer period is necessary if the film is air-dried. Unless the investment is quite free of the cellulose triacetate solvents, the ethyl silicate, which is brushed over it, will form into tiny droplets, which do not ruin the separating film but serve no useful purpose and require a longer time to dry. Sometimes if two or three additional coats of ethyl silicate are applied, droplet formation will not take place. The ethyl silicate film will dry in 10 to 15 minutes depositing a layer of silica (SiO_2). Silica has the properties of a good separating medium because it is waterproof, heat-resistant and chemically inert except to hydrofluoric acid and strong alkalis.

Results

We have made several dentures and flat plastic plates using this separating medium. In every case there was good separation from the mold and a fairly smooth surface on the plastic pieces. The smoothness of the surfaces of the plastic is of course limited by the smoothness of the mold surfaces. Some buffing or polishing must be done and certainly the flashes, produced by a compression molding technique, must be ground off.

The cellulose triacetate film usually remains on the mold but some of the silica comes off on the plastic. It comes off readily, however, when the plastic is polished.

Cellulose triacetate by itself is a fair separating medium but, when used alone, we found it tended to come away with the plastic and had to be peeled off - not a difficult task.

The clarity of transparent plastic made with this separating medium is good, but it is not as excellent as that made with tinfoil.

We hesitate to advocate the general use of this separating medium in place of tinfoil but we recommend its trial by the dental profession, who should make the final decision regarding its use.

Transverse Strength

The test for transverse strength of denture base plastics in the Tentative American Dental Association Specification No. 12 ensures that the denture is properly cured and that it is tough without being too flexible or too brittle. Since methyl methacrylate is an accepted satisfactory denture base material when properly used, the transverse strength test can be used to check the suitability of any curing cycle.

Figure 1 accompanying this report is a diagram of the apparatus used in making the test. The test piece is supported by two rollers 3.2 mm. (0.125 in.) in diameter and 50 mm. apart. The plunger is supported vertically by a collar and rests on the specimen by another rod also 3.2 mm. in diameter. The plunger is fitted on top with a suitable container for shot used in loading and moves a gauge, reading to 0.01 mm. as the specimen is bent.

The test pieces are accurately ground to size, polished, and then conditioned in water at 99°F. from 2 to 4 days before testing.

The dimensions of the specimen are 2.50 x 10.0 x 65 mm., with a tolerance of 0.01 mm. on the thickness and width.

An initial load of 1500 grams is applied to the specimen. The dial is adjusted to zero or the bending of the specimen under this load is taken as the base-line deflection. Then a load increment of 500 grams is gradually applied over a 30-second interval and the deflection recorded 30 seconds later. This procedure is repeated until the specimen breaks or is forced through the 50-mm. span.

In relating deflections with strength, it will be found usually that the weakest material has the largest deflection. The combination of strength (load) and bending (deflection) may be considered an index of the toughness of the material. A very tough material, therefore, can be considered as one having great strength and at the same time a relatively large deflection before failure. A brittle material might be equally as strong but would have a small deflection.

To eliminate weak and brittle materials, the specifications for this test require that the specimen show the following deflections:

"K-5"

At 4000 grams - 2.6 mm. (maximum)

At 6000 grams - 3.0 mm. (minimum - 8.0 mm.
(maximum))

6000 grams. In addition, the maximum load must be at least

We wish to determine if a denture made by the "anti-porosity cycle" is sufficiently cured when the water bath reaches 212°F. and, if not, how much longer does the cure need to be prolonged at this temperature.

Fat plastic plates measuring 3x 45 x 66 mm. were made in a regular dental flask using two brass thermocouples 8 x 45 x 65 mm. - one in each half of the investment. A trial run was made with two thermocouples in such a plate to determine whether it received a curing treatment similar to that received by a denture made under the same conditions. This was found to be the case and the curve obtained was very much the same as the graph of the temperatures in the palate of a denture as indicated in the graph in Report No. 4607.

All plates were made of Lucitone powder and liquid and were processed against a separating medium of cellulose triacetate and ethyl silicate as previously described. When the heat treatment was completed, the flask was bench-cooled for 15 minutes and then cooled for another 5 minutes in cold running water. Specimens were cut from the plates, ground to exact dimensions, polished and then conditioned for 2 days in water at 99°F. before testing. Since the softening point of methyl methacrylate (Lucitone) is very high (about 185°F.) the transverse strength is independent of temperature in the region of room and body temperatures. So although the specification calls for the tests to be made in air at 99°F. we conducted them at room temperature (about 75°F.)

The following cures were carried out:

1. "Anti-porosity cycle" up to 212°F.
2. "Anti-porosity cycle" to 212°F. - at 212°F. for 1/2 hour.
3. 2-1/2 hours at 160°F.
4. Room temperature to 212°F. in one hour - at 212°F. for 15 minutes.

"K-6"

Cures 3 and 4 were made for comparison. Cure 3 was once advocated by a commercial manufacturer of denture base materials but was later withdrawn as unsatisfactory. Cure 4 is similar to that formerly taught by the Canadian Dental Corps except that the period at 212°F. is cut to 15 minutes from 45 minutes.

A table presents the results. Figures are averages of the values from 3 specimen.

Deflections in mm.

Load (grams)	(1) "Anti-porosity Cycle"to 212°F.	(2) "Anti-porosity Cycle"-at 212°F. 1/2 hour.	(3) 2-1/2 hrs. at 160°F.	(4) R.T.to 212°F. in 1 hr.-at 212°F. 15 minutes.
1500	0	0	0	0
2000	0.4	0.3	0.4	0.4
2500	0.8	0.7	0.9	0.8
3000	1.2	1.1	1.4	1.3
3500	1.6	1.6	1.9	1.8
4000	2.1	2.1	2.5	2.3
4500	2.6	2.6	3.3	2.9
5000	3.2	3.2	4.0	3.6
5500	3.8	3.9	5.3	4.3
6000	4.6	4.6	7.3*	5.4
6500	5.4	5.6	-	6.6
7000	6.9	7.4	-	8.9
7500	-	-	-	-
Av. Max. Load	7000 grams	7400 grams	6000 grams	7200 gram

* Average of two results. One specimen broke at 5850 grams.

"K-7"

These results are plotted on a graph on which are marked by arrows the specification limits. It will be seen that all cures pass the test. Cure 3, however, lies very close to the lower specification limit and one of the specimens broke before the upper limit was reached. If this average was maintained for a greater number of specimens, this cure would obviously be unsatisfactory.

The other three cures are quite satisfactory and there is little difference between 1 and 2 except a slightly higher maximum strength. This shows that for practical purposes there is no advantage to be gained by prolonging the cure for the "anti-porosity cycle". Cure 4 is quite satisfactory if the heating is stopped after 15 minutes at 212°F.

It should be remembered that these cures were made with two thermoduets in the mold investment. If these thermoduets are not used, the transverse strength results may be quite different, since the heat conductivity of the investment will be altered.

Summary of Transverse Strength Tests

1. The "anti-porosity cycle" is a satisfactory curing technique for dentures.
2. There is no great advantage in continuing to cure a denture by the "anti-porosity cycle" after the water-bath reaches 212°F.
3. A long cure of 2-1/2 hours at 160°F. does not produce a denture strong enough to pass the transverse strength test.
4. Curing a denture by heating slowly (1 hour) to 212°F. and holding the temperature at 212°F. for 15 minutes is a satisfactory technique providing, of course, that porosity is avoided.
5. The transverse strength tests presented here were made with thermoduets in the mold investment.

Remarks on Technique

(a) Use of Thermoduets - The "anti-porosity cycle" makes use of two thermoduets - a standard thermoduct in the tooth-half of the investment and a specially shaped one for the model-half which is in close contact with the bottom of the flask. These thermoduets conduct away the

heat of polymerization in the denture base material, thus avoiding peak temperatures, aiding to prevent porosity and localized strains caused by differences in degree of polymerization.

In practice, several such thermoduets of various shapes could be part of a dental technicians equipment. As a suggestion, they might possibly be made to correspond to the different impression trays which a dentist requires.

(b) Compensation for Curing Shrinkage - Since methyl methacrylate shrinks on curing, it is advisable to pack a slight excess of resin in the flask. If this is done, the final flask closure produces a heavy flash where the mold halves meet. Some workers complain that a heavy flash tends to cause "an open bite". This thick flash can be avoided if two or three small channels are cut in the land of the investment to the walls of the dental flask where there are two or three corresponding grooves to the outside of the flask.

(c) Cooling and Strains - Rapid cooling may cause checked teeth and internal strains in the denture resin. Because the plaster, the teeth (porcelain) and the resin all have different coefficients of thermal expansion, it is impossible to remove strains entirely by an annealing process. However, if cooling is carried out slowly, strains will be minimized.

In the "anti-porosity cycle", the investment contains thermoduets of high heat conductivity. These thermoduets will control cooling just as they control the heat of polymerization, by elimination of temperature differentials.

To accomplish slow cooling, the flask may be allowed to cool with the water-bath or it may be bench-cooled for about 15 minutes and then immersed in cold running water for another 5 minutes before opening.

Suggestions for Denture Making After Wax Removal

1. Allow the mold to cool to room temperature.
2. Brush on several coats of a 3 per cent cellulose triacetate solution in 80:20 chloroform:ethyl alcohol until a smooth film is visible. Avoid coating the teeth as much as possible.

"K-9"

3. Allow the film to dry thoroughly. Warm air can be blown over it or the flask placed in a warm (150°F.) oven for about 15 minutes.
4. Brush on ethyl silicate solution. Do not allow this solution to collect in any mold depressions and avoid the teeth as much as possible.
5. Pack the flask with a slight excess of resin, allowing the excess to escape by way of several small channels to the outside of the flask.
6. Place the flask in water at 120°F. Heat to 175°F. in 10 to 15 minutes. Change the water-bath to cold tap water (or immerse the flask in another bath). Heat to 212°F. in 25 to 30 minutes. No adjustment of-the heater (gas burner etc) should be necessary.
7. Cool the flask slowly in the bath or bench-cool 15 minutes and then water-cool for 5 minutes.
8. Grind off the flashes, trim around the teeth and finish by polishing and buffing.

Summary of Work on Methyl Methacrylate

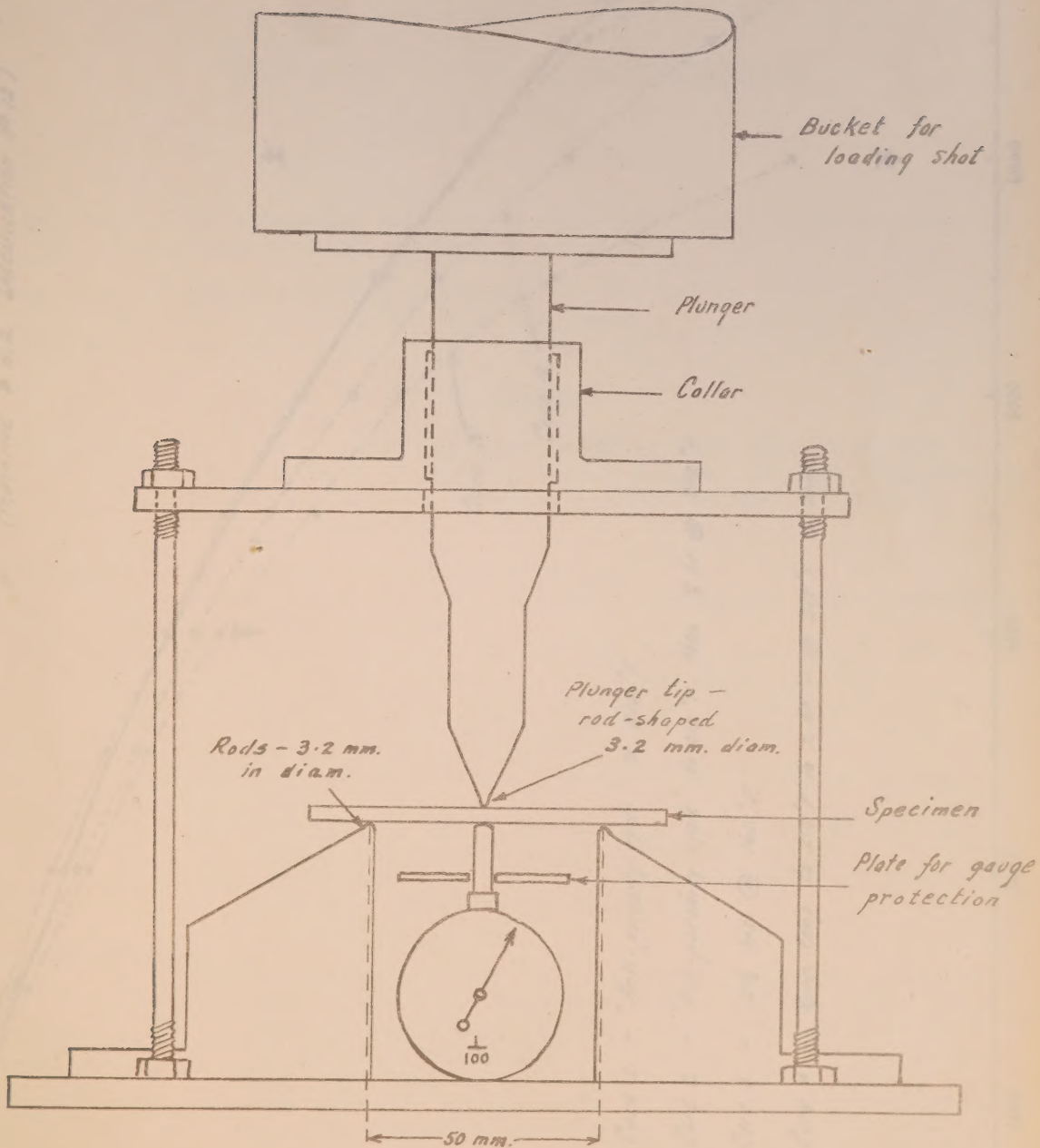
We have investigated the physical properties of methyl methacrylate and in particular Lucitone denture base material. It is a satisfactory substance when correctly used. We have developed a rapid curing technique which controls the heat of polymerization, prevents porosity and to some extent the development of internal strains. We offer for trial a separating medium of cellulose triacetate and ethyl silicate which may also eliminate considerable work in grinding and finishing dentures.

In view of these facts, it does not seem profitable to continue with investigations on methyl methacrylate denture base materials.

Future Work

1. Investigation of other processes, such as Luxene.
2. Investigation of other plastics.

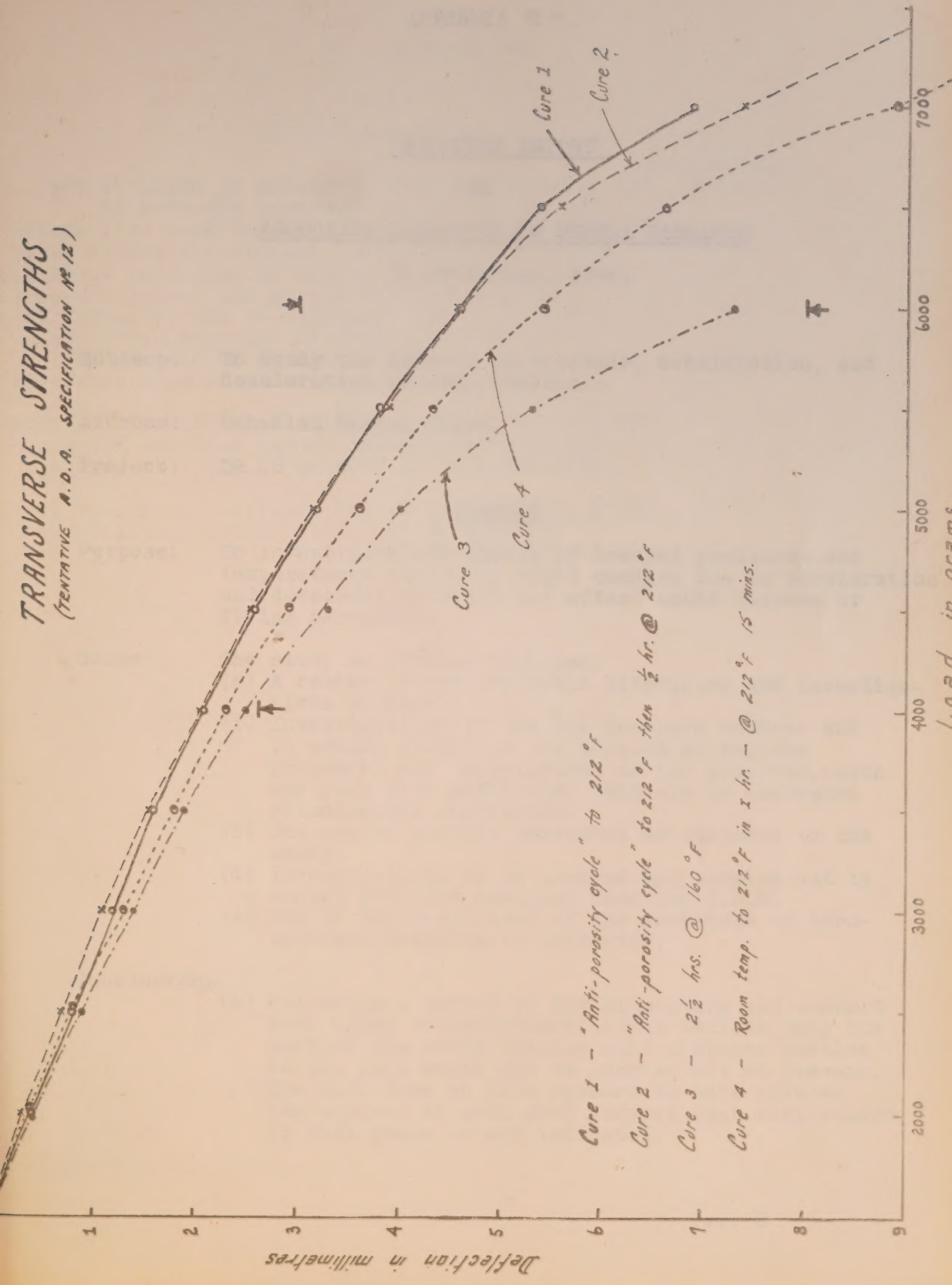
October 8, 1946.



— Figure 1 - Transverse Strength Test Apparatus.

TRANSVERSE STRENGTHS

(TENTATIVE A. D. A. SPECIFICATION No 12)



APPENDIX "L"

MID-YEAR REPORT

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

30 September, 1946.

Subject: To study the effects of altitude, acceleration, and deceleration on oral tissues.

Authors: Canadian Dental Corps.

Project: DR 6

SUMMARY

Purpose: To investigate all phases of lowered pressures and temperatures including rapid changes due to acceleration and deceleration which may affect mouth tissues of flying personnel.

Scope: The study as planned included:

- (a) A review of the available literature and investigations to date.
- (b) Investigations in the low pressure chamber and in actual flight of the effects of varying pressures and temperatures on the gingivae, teeth and pulp with particular emphasis on untreated pathological conditions.
- (c) The use of service personnel as subjects in the study.
- (d) Investigations to be planned and carried out by dental officers assigned from the C.D.C.
- (e) Use of the facilities of the Institute of Aeronautical Medicine at Eglington.

Conclusions:

- (a) Following a review of the literature and contact with other investigators it was decided that the part of the study dealing with nitrogen bubbles in the pulp would not be carried out at present. The work done to date appears to have covered the subject to such good purpose that continuance of this phase is not indicated.

- 2 -

MID-YEAR REPORT

Conclusions:

- (cont'd) (b) Arrangements were completed on Sept. 16 for the use of the low pressure chambers at Eglington, and it is expected work will start as soon as possible. Unavoidable delays have been experienced because of unsettled conditions in the armed forces during the transition period incident to the formation of the permanent force. It was also necessary to postpone operations until the trained personnel to operate the equipment at Eglington could be made available.
- (c) The actual direction of the study will be under the Director General Dental Services N.D.H.Q. with Major B. P. Kearney, M.B.E., in charge.
- (d) A grant-in-aid is not required at present as it is intended to utilize service facilities as far as possible.

Date:

30 September 1946.

Conclusions:

(a) Following a review of the literature and contact with other investigators it was decided that the part of the study dealing with nitrogen bubbles in the pulp would not be carried out at present. The work done to date appears to have covered the subject to such good purpose that continuance of this phase is not indicated.

APPENDIX "M"

MID-YEAR REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

15 September, 1946.

Subject: Investigation and Report on Dental Caries Research.

Author : J. Stanley Bagnall

Project No.: DR 7

SUMMARY

Purpose: Critical investigation of research on dental caries.

Scope: Up to present about 1200 articles have been reviewed. Approximately 900 of these have been reduced to précis form and arranged in sections. These notes are being extensively cross indexed in preparation for the report. It is hoped that, if necessary time can be made, the literature review part will be brought pretty well up to date this Winter.

Conclusions: -

Signature:

"J. Stanley Bagnall"

DATE: Sept. 27, 1946.

"7-3"

BRANTFORD PUBLIC SCHOOL SURVEY

APPENDIX "N"

REPORT ON BRANTFORD FLUORINE SURVEY

Conducted

by

H.A. HUNTER

Introduction

In view of the widespread interest and investigation into the effects of fluorine on the incidence of caries that is being evidenced in many parts of the world, it was an opportune moment to undertake the present study.

The city of Brantford, Ontario, started to put fluorine into its water supply in November 1945 to the extent of 1 p.p.m. and the examination was conducted to obtain an overall picture of the dental condition of a representative group of children before any changes might be brought about by the addition of fluorine.

The plan adopted was to choose at least 100 children in each of the age groups of 5, 7, 9, 11, and 13 years. Any lesser number it was felt would be insufficient from a statistical point of view and, though a greater number would have been desirable, it would have greatly increased the cost of the program.

In order to round out the study it would be advisable to conduct a similar examination in a community of comparable size where there is known to be a natural fluorine content in the municipal water supply of between 1 and 1 1/2 p.p.m. A control group in another city of comparable size and in the same vicinity should be included where there is as little as possible fluorine in the water supply; where the water supply has been the same for the past 15 years, and where there is little likelihood that fluorine will be added in the next 10 years.

If these three centres are examined at intervals over a period of some 10 years, a comparative analysis could be made which would give an accurate picture of the possible effect of fluorine on the incidence of dental caries.

BRANTFORD PUBLIC SCHOOL SURVEY

1. Age		5	7	9	11	13
2. Number examined		100	100	92	100	100
3. Sex		44M 56F	49M 51F	48M 44F	44M 56F	56M 44F
4. No. free from defects		15	2	2	0	2
5. No. with carious lesions (1-3)	Permanent	9	42	45	50	23
6. " " " (4-9)	"	2	24	38	35	44
7. " " " (10 and over)"	"	0	0	1	6	30
8. " " " (1-3)	Deciduous	24	18	33	26	6
9. " " " (4-9)	"	25	53	46	17	2
10. " " " (10 and over)"	"	33	23	10	5	0
11. No. of pit cavities	Permanent	18	190	201	226	407
12. " " proximal cavities	"	0	14	63	106	232
13. " " buccal and lingual cavities	"	0	6	20	30	59
14. " " pit cavities	Deciduous	180	130	58	26	5
15. " " proximal cavities	"	470	505	369	164	17
16. " " buccal and lingual cavities	"	55	57	27	11	1
17. No. with fillings (1-3)	Permanent	0	12	25	16	20
18. " " " (4-9)	"	1	5	36	52	46
19. " " " (10 and over)	"	0	0	3	7	24
20. " " " (1-3)	Deciduous	13	22	33	11	2
21. " " " (4-9)	"	11	25	12	4	1
22. " " " (10 and over)	"	3	1	0	0	0
23. No. of pit fillings	Permanent	5	39	261	346	515
24. " " proximal fillings	"	0	1	20	62	139
25. " " buccal and lingual fillings	"	0	4	4	12	24
26. " " pit fillings	Deciduous	71	91	48	20	4
27. " " proximal fillings	"	58	114	64	24	2
28. " " buccal and lingual fillings	"	4	5	6	0	1
29. " " missing teeth	Permanent	0	0	14	33	56
30. " " " "	Deciduous	17	59	39	0	0
31. " " teeth requiring extraction	Permanent	0	0	7	9	29
32. " " " " " "	Deciduous	41	81	47	21	12
33. Percentage of 1st molars in column No.29		0	0	23	50	68
34. No. of retained deciduous fragments		0	4	24	29	11
35. No. of cases of enamel hypoplasia		2	1	3	2	3
36. No. of cases of mottled enamel		1	3	7	15	19
37. No. of situations requiring space maintainers		3	37	39	14	28
38. No. of cases of abnormal molar relationship		2	9	12	20	26
39. Calculus - none		86	60	34	21	20
40. " - slight		14	37	61	73	63
41. " - abundant		0	3	5	6	17
42. Shape of arches - normal		79	47	43	48	51
43. " " - narrow		14	49	50	48	43
44. " " - wide		7	4	7	4	6
45. Oral hygiene - good		44	34	24	32	37
46. " " - fair		51	52	56	47	38
47. " " - poor		5	14	20	21	25
48. No. of cases of green stains		21	16	29	28	21
49. Gingival condition - Grade I		41	59	61	46	49
50. " " - Grade II		2	19	28	27	30
51. " " - Grade III		0	2	0	4	6
52. No. of cases of mouth breathing		1	1	2	8	13

"N-3"

SURVEY OF SELECTED BRANTFORD SCHOOL CHILDREN

TABLE II

<u>Age</u>	<u>Total No. Examined</u>	<u>Teeth Filled</u>	<u>Teeth Carious</u>	<u>To be Extracted</u>	<u>Missing</u>	<u>D.M.F.</u>
5	100	107	533	38	10	6 X.88
7	100	193	678	80	24	9.75
9	92	280	582	73	13	9.48
11	100	280	414	59	35	7.88
13	100	423	545	37	56	10.61

"N-4"
APPENDIX

This study was conducted in March 1946 on children from all fourteen Public and Separate Schools in the city of Brantford, Ontario. All children accepted for examination were born in and have been continuous residents of that city.

All children in this study were examined with the aid of a mouth mirror and explorer: the figures in the attached analysis are based on this method of examination.

Two age groups, i.e. the seven and eleven year olds, were further examined by taking posterior bite-wing radiograms. In the seven year group there were 126 additional interproximal lesions discovered, of which 112 were in the deciduous teeth and 14 in the permanent. In the 11 year group there were 93 additional interproximal lesions, of which 22 were in the deciduous dentition and the remaining 71 were in the permanent teeth.

No.2 In the nine year group the figures have been adjusted to a percentage basis for comparison with the other groups.

" 4 Defects in this column are considered to be only the D.M.F.

" 5 This includes all types of carious lesions.

" 11 Pit cavities in this case include all retention pits both occlusal and buccal. Any number of carious pits on the one surface are considered as only one cavity.

" 12 This includes proximal and proximo-occlusal cavities.

" 13 This includes labial, buccal and lingual smooth surface cavities.

" 29 Includes extracted teeth and those well past their normal eruption time.

" 34 Includes those deciduous teeth where the permanent tooth is also present in the mouth.

" 36 Includes all cases of isolated and unsymmetrical white and brown spots.

" 37 Indicated only when required at time of examination; does not include cases where it would be required if the necessary surgery was done to remove hopelessly diseased teeth.

" 38 Considered abnormal when either or both sides showed either a mesial or distal displacement of one cusp width.

" 49 This includes those cases where the mucosa is just off normal pink colour, or at most, showing a slight marginal gingivitis.

" 51 These are cases where there is marked inflammation, hypertrophy, redness, loss of stippling entirely and haemorrhage on the slightest touch.

APPENDIX "O"

MID-YEAR REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

15 September, 1946

Subject: An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

Authors: Dr. O. J. Walker and Dr. H. R. MacLean

Project
No.: DR 9

SUMMARY

Purpose: Progress on this project has not been so rapid as anticipated as it was not possible to obtain a suitable research assistant this year for summer work. Preliminary work has been carried out in ascertaining the composition of some of the dental alloys in use as well as that of several of the cleansing agents. Arrangements are being made for securing test pieces of dental alloys and synthetic resins to be used in corrosion tests. Research on this project will be carried out during the winter months on a part time basis by Miss Dorothy Coggles, B.Sc. with First Class Honors in Chemistry, who is one of our Sessional Instructors. It is hoped that the grant will be continued into 1947-1948 so as to allow the securing of a full-time assistant for the Summer of 1947.

Scope:

Date: October 11, 1946.

Signature: "O.J.Walker"

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NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
SECOND MEETING
OF THE
EXECUTIVE
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

24 FEBRUARY, 1947

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Initial Distribution

Consideration of Business Arising from the Proceedings of the Fourth Meeting of the Associate Committee

(1) Descriptive pamphlet (1948 No. 1 Min. 6)

THE CHAIRMAN reported that following the distribution of the Descriptive pamphlet he had received numerous letters of comment. He read several of these to the members. One of these letters suggested further research in relation to fluorine from the point of view of the effect on nutrition. Dr. KILL pointed out that surveys of the efforts of fluorine on teeth could not be carried out under the auspices of the Committee but he had brought this subject to the attention of Dr. JONES and had been assured that the Department of National Health and Welfare would give favorable consideration to such projects.

DR. JONES thought it would be useful to have the Bradford survey paralleled by one in another area as a check to determine the validity of the Bradford results.

DR. JONES said he was prepared to go ahead with the survey program. Dr. JONES of Alberta is joining his staff and will be available to do work of this kind. He agreed that it would be necessary to have a control centre in which there is no fluorine in the drinking water as well as areas in which fluorine occurs.

DR. CHARTER expressed the view that the Committee might return the appreciation of the initiative shown by the Department of National Health and Welfare in supporting survey studies on the

Proceedings of the Second Meeting

of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber

NATIONAL RESEARCH BUILDING

2 p.m., Monday, 24 February, 1947.

1. Attendance

Dr. R. G. Ellis, Chairman
President C. J. Mackenzie (ex officio)
Dr. E. Charron
Dr. L. V. Janes
Dr. D. L. Thomson

Mr. S. J. Cook, Secretary

2. Consideration of Business Arising from the Proceedings
of the Fourth Meeting of the Associate Committee

(1) Descriptive pamphlet (4th Mtg.: Min. 6)

THE CHAIRMAN reported that following the distribution of the descriptive pamphlet he had received numerous letters of comments. He read several of these to the members. One of these letters suggested further research in relation to fluorine from the point of view of its effect on nutrition. Dr. Ellis pointed out that surveys of the effects of fluorine on teeth could not be carried out under the auspices of the Committee but he had brought this subject to the attention of Dr. Janes and had been assured that the Department of National Health and Welfare would give favorable consideration to such projects.

DR. THOMSON thought it would be useful to have the Brantford Survey paralleled by one in another area as a check to determine the validity of the Brantford results.

DR. JANES said he was prepared to go ahead with the survey problem. Dr. Brown of Alberta is joining his staff and will be available to do work of this kind. He agreed that it would be necessary to have a control centre in which there is no fluorine in the drinking water as well as areas in which fluorine occurs.

DR. CHARRON expressed the view that the Committee might record its appreciation of the initiative shown by the Department of National Health and Welfare in projecting survey studies on the

subject of fluorine and said that he thought the Committee should be willing to cooperate in providing advice in regard to such projects.

(ii) Gas Delivery Apparatus (4th Mtg.: Min. 5(i))

THE CHAIRMAN reported that no manuscript had been received on project DR 2 from Dr. Lucas as yet. It had been suggested that the Dominion Council of Health might be a suitable organization to take action on any recommendation made by the Committee regarding the inspection of gas delivery apparatus used for anaesthesia and he had been assured that this subject would be considered at the next meeting of the Dominion Council.

(iii) Acrylic Resin Denture Base (4th Mtg.: Min.5(vi))

THE CHAIRMAN reported that an application had been received from the Ontario Research Foundation for work on acrylic resin denture base to study inlay cements and that the application had been granted following approval of the Executive by mail.

(iv) Editorial on Dental Research (4th Mtg.: Min.7)

THE CHAIRMAN said that Dr. Garvin had prepared and published an editorial entitled Dentistry and Research and that reprints had been sent to the Dental schools for distribution to the members of graduating classes.

3. Budget

THE CHAIRMAN reported that in 1946-47 the Committee had \$25,000. at its disposal and that for 1947-48 he had recommended a budget of \$30,000. which included \$500. for contingencies, \$2,000. for Committee travel and \$27,500. for grants-in-aid. The total sum has been placed in the estimates of the National Research Council.

4. Applications for Grants-in-Aid, 1947-48

DR. THOMSON suggested that the Committee should be strict in the application of the rule that all applications for grants-in-aid must be in the hands of the Secretary by 1 February in order to be considered.

It was MOVED by Dr. Charron and SECONDED by Dr. Thomson

That the Executive recommends that in general, all applications for grants-in-aid be filed with the Secretary of the Committee by 1 February in each year and that the Chairman of the Committee be authorized to select suitable referees to report on applications.

CARRIED.

It was also AGREED that, in future, reports on grants-in-aid must be in the hands of the Secretary of the Committee by the date set and that failure to do so will jeopardize the making of any grants that may be requested.

THE PRESIDENT suggested and it was AGREED that special committees should be appointed to report on each project that has been carried on over a period of years, to determine whether the work should be continued further.

5. Applications for Renewal of Grants, 1947-48

DR 1	Dr. J. J. Rae	No application*
DR 2	Dr. G.H.W. Lucas	Chemical study of Nitrous oxide for dental anaesthesia. Recommended. \$1900.
DR 3	Dr. H. K. Box	Micro-organisms in deep periodontal pockets. (Renewal, no money spent) Recommended. \$ 500.
DR 4	Dr. H. K. Box	Packing material in the treatment of periodontal disease. Two grants were made last year, one for work on packing materials and one for bacteriological studies. This year a separate grant has been requested for the bacteriological work. Recommended. \$2200.
DR 5	Major R.L. Twible	No application*
DR 6	Col. D. S. Coons	No grant required
DR 7	Dr. J. S. Bagnall	No application*
DR 9	Drs. O.J. Walker and H.R. MacLean	Materials in prosthetic dentistry. No application *
DR 10	Dr. G.M. MacDonald	No application
DR 11	Dr. R. J. Gedfrey	No application *
DR 12	Dr. A.E.R. Westman	No application *

* Application subsequently received and considered by the Committee.

6. New Applications, 1947-48

- (i) Dr. M. Doreen Smith Methods of fluorine analysis. \$1050.

DR. THOMSON expressed doubt that the study of methods of analysis came within the scope of the Committee's functions. He expressed the view that if a method had been worked out and was to be applied in a dental problem, the subject might be of interest to the Committee.

- (ii) Dr. M. Doreen Smith Fluorine analyses of water and food samples from different areas in relation to dental caries. \$1125.

DR. THOMSON said that he thought satisfactory information was already available on fluorine analyses of water but that not much work had been done on milk and other foods and that this might be of interest. However, if it was intended to spend several months in the study of new methods of fluorine analysis he thought consideration of this project might be deferred. He suggested that the Chairman discuss the matter with Dr. Smith and point out that the Committee was interested in the programme of work proposed but not in the study of methods of analysis.

- (iii) Dr. H. K. Box Experimental production of dental caries. \$1500.

- (iv) Dr. Norma Ford Walker A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches. Recommended. \$3000.

- (v) Dr. C. H. Best The development of culture technique for certain fungus-like organisms found in periodontal disease. Recommended. \$1100.

This is a renewal of a grant for work in continuance of the bacteriological study initiated under DR 4 last year.

7. Congratulations

DR. CHARRON drew the attention of the Executive to a recent announcement that the Chairman of the Committee, Dr. R.G. Ellis, has been appointed Dean of the Faculty of Dentistry at the University of Toronto and is to take office 1 July 1947. Members of the Executive expressed their congratulations to the Chairman on his new appointment.

The Meeting adjourned at 5 p.m.

5. Dr. H. H. Jones 31 March, 1947
6. Dr. W. H. Martin 31 March, 1947
7. Dr. W. J. Lingshorne 31 March, 1947
8. Dr. H. H. Jones 31 March, 1947
9. Dr. G. H. Jones 31 March, 1947
10. Col. W. H. Macdonald (ex officio) ---
Rep. Division of Dental Health
Dept. Nat. Health and Welfare
11. Dr. L. F. Jones (ex officio) ---
Rep. Basic and Med. Sciences
12. Dr. G. H. Jones 31 March, 1947
13. Dr. W. J. Lingshorne 31 March, 1947
14. Dr. J. H. Jones 31 March, 1947
15. Dr. W. H. Martin 31 March, 1947
16. Dr. J. H. Jones 31 March, 1947
17. Dr. A. H. Jones 31 March, 1947
18. Dr. D. H. Jones 31 March, 1947
19. Dr. G. H. Jones 31 March, 1947
20. Dr. G. H. Jones, Secretary ---
21. Office Copy (General Secretary) ---
22. Board Copy ---
23. Library ---
24. H. H. Jones ---

INITIAL DISTRIBUTION

Term to Expire

- * 1. Dr. R. G. Ellis, Chairman 31 March, 1948
- 2. President C. J. Mackenzie (ex officio) --

Rep. Dental Profession

- 3. Dr. H. K. Box 31 March, 1949
- * 4. Dr. E. Charron 31 March, 1948
- 5. Dr. D. S. Coons 31 March, 1949
- 6. Dr. M. H. Garvin 31 March, 1947
- 7. Dr. W. J. Linghorne 31 March, 1948
- 8. Dr. H. R. MacLean 31 March, 1947
- 9. Dr. G. D. Stibbs 31 March, 1949

Rep. Army Dental Corps

- * 10. Col. W. M. Wansbrough (ex officio) --

Rep. Division of Dental Health Dept. Nat. Health and Welfare

- 11. Dr. L. V. Janes (ex officio) --

Rep. Basic and Med. Sciences

- 12. Dr. C. H. Best 31 March, 1947
- 13. Dr. E. F. Burton 31 March, 1949
- 14. Dr. J. B. Collip 31 March, 1949
- 15. Dr. C. W. Ellis 31 March, 1948
- 16. Dr. J.K.W. Ferguson 31 March, 1948
- 17. Dr. A. R. Gordon 31 March, 1947
- 18. Dr. D. Mainland 31 March, 1948
- * 19. Dr. D. L. Thomson 31 March, 1947
- 20. Mr. S. J. Cook, Secretary --
- 21. Office Copy (General Secretary) --
- 22. Board Room Copy --
- 23. Library
- 24-33 Reserve

* Members of the Executive.

CONFIDENTIAL

COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
FIFTH MEETING
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

25 FEBRUARY, 1947

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Appendices

- A - The Chemical Mechanism of Dental Caries by J. J. Rae, C. T. Clegg, and Miss M. I. Davies.
- B - A Comparison of the Gas Percentage Delivery and Percentage Dial Setting in Anaesthetic Gas Machines by R. J. S. Tickle.
- C - Investigation of Packing Material in the Treatment of Periodontal Disease by H. K. Box, W. J. Linghorne.
- D - Investigations on Methyl Methacrylate Denture Base Material by D. R. Christie.
- E - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. L-4601 by D. R. Christie
- F - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. 4610 by D. R. Christie
- G - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. 4701 by D. R. Christie
- H - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. 4702 by D. R. Christie
- I - To Study the Effects of Altitude, Acceleration, and Decelerations on Oral Tissues by Royal Canadian Dental Corps, (Dr. D. S. Coons)
- J - Investigation and Critical Report on Dental Caries Research by J. S. Bagnall
- K - Effects of Certain Chemicals on Materials Used in Prosthetic Dentistry by Dr. O. J. Walker and Dr. H. R. MacLean
- L - Facial Prostheses by G. M. MacDonald

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Appendices

- M - An Anatomical, Histological and Physiological Study of the Role of the Condyle in Mastication by Charles H. Moses (Grantee Prof. R. J. Godfrey, D.D.S.)
- N - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship, Project No. DR 12 - To Develop an Improved Cement for Methyl Methacrylate Inlays by D. R. Christie.
- O - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. 4701 by D. R. Christie
- P - Ontario Research Foundation (Division of Chemical Research) Dental Materials Research Fellowship Report No. 4702 by D. R. Christie
- Q - Draft By-law Respecting National Research Council Committees.

Initial Distribution

Proceedings of the Fifth Meeting
of the
ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber

National Research Building

9:30 a.m., 25 Feb. 1947

1. Attendance

Dr. R. G. Ellis, Chairman
President C. J. Mackenzie (ex officio)
Dr. H. K. Box
Dr. E. Charron
Dr. J. B. Collip
Dr. D. S. Coons
Dr. O. W. Ellis
Dr. J. K. W. Ferguson
Dr. M. H. Garvin
Dr. L. V. Janes
Dr. W. J. Linghorne
Dr. H. R. MacLean
Dr. G. D. Stibbs
Dr. D. L. Thomson
Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

By invitation

Dr. J. S. Bagnall

Apologies for their absence were received from
Dr. C. H. Best, Dr. A. R. Gordon and Dr. D. Mainland.

2. Chairman's Remarks

THE CHAIRMAN in a few words of welcome expressed his pleasure at seeing so many members of the Committee present at the Meeting. He said that the members were always gratified to have President Mackenzie meet with them. At this Meeting he had invited Dr. J.S. Bagnall to be present and to give a personal report on the project which he is conducting for the Committee.

3. Second Meeting of the Executive

THE CHAIRMAN reported that the second Meeting of the Executive had been held at 2 p.m., on the preceding day to consider the business to be presented at this Meeting of the Committee. He paid tribute to the Secretary who had prepared a full set of Minutes of the Executive Meeting on the previous evening. He asked that the Executive Minutes be read for the information of the members. The proceedings of the Executive are being published separately and will be distributed to all members of the Committee.

It was MOVED by Dr. Thomson and SECONDED by Dr. MacLean:

That the proceedings of the Second Meeting of the Executive be approved. CARRIED.

4. Proceedings of the Fourth Meeting

THE CHAIRMAN said that the proceedings of the Fourth Meeting of the Committee had been distributed to the members.

It was MOVED by Dr. Thomson and SECONDED by Dr. Charron:

That the proceedings of the Fourth Meeting of the Committee, having been circulated, be taken as read and approved. CARRIED.

5. Business Arising out of the Minutes

(i) Descriptive pamphlet - (4th Mtg. Min. 6)

THE CHAIRMAN said that following the distribution of the descriptive pamphlet he had received numerous letters from university professors and others regarding the various points outlined in the booklet. He read extracts from some of these letters.

(ii) Gas delivery apparatus - (4th Mtg. Min. 5(ii))

THE CHAIRMAN said that he had written to Dr. G.D.W. Cameron, Deputy Minister, Department of National Health and Welfare, to inquire as to what organization would have authority to deal with any recommendations made by the Committee regarding regulations to govern the use of gas delivery equipment. Dr. Cameron had promised in reply to bring the matter to the attention of the Dominion Council of Health at its next meeting and to ask their advice on the subject.

(iii) Project on inlay cements - (4th Mtg. Min. 5(vi))

THE CHAIRMAN said that an application had been received for work on this subject from the Ontario Research Foundation and that it had been approved by mail ballot by the Executive and that a report would be presented at this Meeting.

(iv) Editorial on dental research - (4th Mtg. Min.7)

THE CHAIRMAN said that the editorial prepared by Dr. Garvin and published in the Journal of the Canadian Dental Association had been reprinted and copies had been sent to the five dental schools for distribution to members of the graduating classes. Several members said that the editorial had been very well received and that it would serve a useful purpose.

(v) Tropicalization - (4th Mtg. Min. 9)

COL. WANSBROUGH reported that after an extensive search and with the aid of Dr. Coons he had succeeded in finding the report on the tropicalization of dental supplies and equipment. He said that there would be no difficulty about the release of the report to members of the Committee but the report itself was somewhat out of date although parts of it dealing with fundamental problems were still good. It was suggested that Dr. Coons might review and condense the report and that in its revised form it should be included as an Appendix to the proceedings. (The report will appear probably in the proceedings of the next meeting). III

6. Consideration of Reports

(i) DR-1 - Dr. James J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

A short final report for the year, and Interim Report No.3 on this project appear in APPENDIX "A"

(ii) DR 2 - Dr. Geo. H. Lucas

"Chemical study of nitrous oxide for dental anaesthesia"

THE CHAIRMAN pointed out that work under this project consisted of two parts; the water-vapour content of gas for anaesthesia on which it was expected that a paper would be submitted for publication as noted in the proceedings of the previous meeting (4th Mtg. Min. 5(ii)); the second part of the work deals with the gas percentage delivery and the percentage dial-setting in anaesthetic gas machines. The report on this part of the work as prepared by Dr. Tickle appears in APPENDIX "B" was it published?

Discussion

DR. FERGUSON said that in the Hospital for Sick Children in Toronto it had been found that the delivery of gas frequently did not correspond to the dial reading which was a very unsatisfactory

situation. There was no legislation covering delivery requirements of gas machines but it was obvious from the work of Dr. Tickle that regulations of this kind were needed. He hoped that when the present project had been completed it would be possible for the investigators to meet with the manufacturers of the equipment and work out the necessary improvements. He felt that even the manufacturers in many cases were not fully informed regarding the principles involved in the operation of gas machines but he thought they were all anxious to provide first class equipment and he knew that they had the necessary engineering facilities to undertake whatever work might be required in this connection.

THE CHAIRMAN said that the report presented to the Committee indicated that excellent work was being done under the project.

It was MOVED by Dr. Charron and SECONDED by Dr. Coons:

That the Associate Committee on Dental Research having considered the report by Dr. Tickle on project DR 2 "Gas percentage delivery and percentage dial setting in anaesthetic gas machines" desires to place on record its appreciation of the very useful work that has been done under this project and to commend those who have been engaged in this task. *Write* CARRIED.

(iii) DR 3 - Dr. H. K. Box

"Effects of penicillin in deep pockets"

DR. BOX said that he had no report to make on this project as the electron microscope which he had intended to use had not been made available to him during the period and there had been certain other difficulties as well. He understood, however, that the electron microscope was likely to be available very shortly and that it would be possible for him to undertake the proposed investigation in the near future.

(iv) DR 4 - Dr. H. K. Box

"Investigation of packing material in the treatment of periodontal disease"

DR. BOX said that this project had been carried on by Dr. Linghorne who would present an interim report. The report by Dr. Box and Dr. Linghorne appears in

APPENDIX "C"

Discussion

THE CHAIRMAN said that in writing to express his regrets at being unable to attend this meeting of the Committee, Dr. C. H. Best had said "I am most interested in the work of the Committee and I have been able to keep fairly closely in touch with it through Dr. Linghorne who is doing some extremely good work in my Department."

He thought this indicated that the work being done under this research was of high quality.

DR. BOX traced briefly some of the more important points in the history of the development of work in this field. He said: "For many years, periodontal disease was regarded by certain observers as a single pathological entity, and much discussion took place in regard to the site of the primary lesion. It will be recalled that the term "periodontium" is now used in a collective sense to designate the supporting tissues of the teeth. These comprise the gingivae (or gums), the periodontal membrane and the alveolar process. One group of investigators held the viewpoint that the primary lesion of periodontal disease was established in the gingival tissues. Another group held the conception that the primary lesion was to be found in the deeper tissues viz. the periodontal membrane, or the bone. Much of the early work, in an attempt to establish a common theory, failed to recognize the existence of two clinically different types of periodontal disease. In consequence, the findings are frequently applicable only to one or the other of these types.

"At a later date, certain workers in the field of periodontal pathology recognized that there are two main forms of periodontal disease and, in general, under various nomenclatures, there is agreement on their clinical description. In the first, gingival inflammation is conspicuous, the pockets tend to develop in a broad and shallow manner, and the progress of the disease is slow. Increased mobility of the tooth in its socket is relatively a late sign. In the second, and in its purest form, the gingival tissues show little inflammation, and may appear almost normal, or pale and thin, with very little tendency towards recession in the early stages. The progress of the disease may be rapid. The involved teeth in certain situations tend to become displaced, and the pockets, when formed, are usually narrow and deep. Tooth mobility is frequently an early sign.

"It has been more or less generally accepted that the first, or progressive gingivitis type is of local origin, and that the second type is of systemic origin, with the primary changes in the periodontal membrane or bone.

"According to our present conception, two processes are involved in periodontal disease, first, inflammation originating in the gingival tissues, and second, a necrotizing process which affects the bone, periodontal membrane and cementum. These deeper destructive changes are produced by enzymes elaborated in the pocket and carried inwards by the lymphatics. It is well known that the inflammatory process shows very little tendency to invade the periodontal membrane but constantly involves the bone marrow. The necrotizing process, on the other hand, usually advances into the periodontal membrane, and this event is probably governed by the course of the lymphatics leading from the pocket.

"Marked gingival inflammation seems to exert a protective action against the necrotizing process. Furthermore, the latter process when established in the deeper tissues appears to be unaccompanied by inflammatory reaction. With this understanding of the two processes involved, the diverse clinical manifestations of the two main forms of periodontal disease are more readily explained."

DR. GARVIN inquired whether any consideration had been given to the economic significance of this particular research but it seemed to be the general opinion that it would not be possible to assess its value on this basis.

DR. FERGUSON complimented the grantees on the work they were doing.

It was MOVED by Dr. Ferguson and SECONDED by Dr. Charron:

That the Committee express its general approval of project DR 4 and of the work done to date as reported by Dr. Linghorne and Dr. Box.

CARRIED.

Copies of a paper by Dr. Box entitled "New aspects of periodontal research" were distributed at the Meeting and a copy is included with the report by Dr. Box and Dr. Linghorne in

APPENDIX "C"

(v) DR 5 - Major R. L. Twible

"Acrylic resin denture base"

THE CHAIRMAN read a report on this project prepared by Douglas R. Christie, Research Fellow. The report appears in

APPENDIX "D"

Discussion

THE CHAIRMAN said that he was a member of a local committee that met once a month to discuss this project and to receive interim reports. Copies of these reports are also sent to the National Research Council and have previously been published in the proceedings of the Associate Committee. The reports received since the last meeting and which are included in the proceedings of this meeting are as follows:

Report L-4601 dated 2 December, 1946 appears in	APPENDIX "E"
Report 4610 dated 10 December, 1946 appears in	APPENDIX "F"
Report 4701 dated 13 January, 1947 appears in	APPENDIX "G"
Report 4702 dated 6 February, 1947 appears in	APPENDIX "H"

(vi) DR 6 - Dr. D. S. Coons

"Effects of altitude change on oral tissues"

DR. COONS presented a report on the work done under this project under the auspices of the Royal Canadian Dental Corps. The report appears in APPENDIX "I"

DR. COONS pointed out that this project was planned and is being carried out by the Royal Canadian Dental Corps with which he is no longer associated since he has been retired from the Service. He suggested therefore that the name of the grantee should be changed and that the project should be recorded in the name of Col. Wansbrough.

THE CHAIRMAN asked Col. Wansbrough if this change would be agreeable to him.

COL. WANSBROUGH said that as the work was a responsibility of the Royal Canadian Dental Corps he supposed it would be in order to have the grant placed in his name and this change was APPROVED.

(vii) DR 7 - Dr. J. S. Bagnall

"Critical survey of the literature on dental caries"

DR. BAGNALL presented his own report which appears in APPENDIX "J"

Discussion

THE CHAIRMAN inquired as to when Dr. Bagnall thought he would be able to present a final report.

DR. BAGNALL said that he hoped to get much work done during the coming summer. He thought it would be helpful to bring out the bibliography and an index first and a review of the material later. He expected to have at least 1300 references in the main bibliography. He had tried to cover all scientific literature in which there might be references of interest in connection with the study of dental caries.

DR. BOX said that as yet there was no agreement as to exactly what caries is but he hoped that the work he was about to undertake using the electron microscope would enable him to establish a clearer definition of the subject.

After some discussion it was MOVED by Dr. Linghorne and SECONDED by Dr. MacLean:

That copies of the bibliography be made available as soon as possible to members of the Committee. CARRIED.

DR. BAGNALL said that the bibliography would have to be retyped and that he could arrange to have extra carbon copies made which could be sent to the Secretary and made available on loan to any of the members.

DR. THOMSON suggested that the Executive might be asked to explore the possibilities of publication of the bibliography and to bring in a report on the subject. It was AGREED that this should be done.

(viii) DR 9 - Drs. O.J. Walker and H.R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

DR. MACLEAN presented a brief report on this project which appears in
APPENDIX "K"

Discussion

DR. O.W. ELLIS suggested that the grantees might find it worthwhile to consult the International Nickel Company who have been operating corrosion research laboratories for the last twenty-five years and who have very good research men in this field of work both in New York and Toronto.

THE SECRETARY said that the National Research Council also has a well equipped corrosion laboratory.

DR. MACLEAN later visited the corrosion laboratory in the National Research Building and had an interesting discussion with the research men in charge. He said also that he would communicate with the International Nickel Company as Dr. Ellis had suggested.

(ix) DR 10 - Dr. G. M. Macdonald

"Facial Prostheses"

A report on this project appears in
APPENDIX "L"

THE CHAIRMAN reported that no funds had been drawn under this grant during the present year.

(x) DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological study of the role of the condyle in mastication"

A report on this project appears in
APPENDIX "M"

DR. THOMSON expressed the opinion that rodents are not good animals to use for comparison with humans because their jaw actions are different.

(xi) DR 12 - Dr. A.E.R. Westman

"Investigation of cements for methacrylate inlays"

A report prepared by Douglas R. Christie, Research Fellow, on the progress made in this research appears in APPENDIX "N"

THE CHAIRMAN said that this was a new project which had been suggested in discussions at the regular monthly meetings held in Toronto to consider progress on the researches being carried on by the Ontario Research Foundation for the Associate Committee on Dental Research. The project had been approved by letter ballot of the Executive in December 1946. As evidence of the interest in the development of cements for methyl methacrylate inlays he mentioned that he had received an inquiry from a commercial firm in the United States who said they were interested in developing such cements. They wished to know from him what six shades he would recommend if they succeeded in making satisfactory cements for this purpose. This is exactly the type of work that is being done under this project.

The question arose as to how high a temperature a patient can stand in the application of the heated cements. At a meeting in Cleveland which he had attended the Chairman said that one speaker had expressed the view that the temperature tolerance of tooth pulp was limited to 40 seconds at 135°F. Neither the time nor this temperature could be exceeded without causing damage.

DR. FERGUSON said that the maximum temperature tolerance in the treatment of internal organs was 120°F. He thought that 135°F was rather high.

DR. BAGNALL said he thought he could find an article on this subject in his bibliography and if so he would bring it to the attention of Dr. Westman.

THE CHAIRMAN stated that two additional progress reports on this research had been received from the Ontario Research Foundation and would be included in these proceedings for the information of the members. These are as follows:

Report 4701 dated 13 January 1947, appears in APPENDIX "O"

Report 4702 dated 6 February 1947, appears in APPENDIX "P"

Luncheon adjournment 12:30 - 1:15 p.m.

7. Finances

(i) Confirmation of grant DR 12

This grant had been recommended by the Executive in a mail ballot and the action taken by the Executive in making a grant of \$825. to Dr. A.E.R. Westman for "The Investigation of Cements for Methacrylate Inlays" was APPROVED.

(ii) Financial statement

THE CHAIRMAN said that he had reported on the budget to the Executive but for the information of the Committee he would repeat the figures. In 1946-47 the Committee had \$25,000. at its disposal and for 1947-48 he had recommended a budget of \$30,000. which included \$500. for contingencies, \$2,000. for Committee travel and \$27,500 for grants-in-aid. He had been advised that the \$30,000. had been placed in the estimates submitted to Parliament by the National Research Council but as members knew no funds had yet been voted by Parliament for 1947-48.

8. Procedure in Dealing with Applications

(i) Exclusion of applicants during consideration of applications. Feb 1948

DR. COLLIP said that in the Advisory Committee on Medical Research it was the practice to ask any applicants for grants who were present at the Meeting to leave the room while their applications were being considered by the Committee. He thought this was a good rule.

It was MOVED by Dr. Collip and SECONDED by Dr. Ferguson:

That if an applicant is present at a meeting at which his application for a grant-in-aid is being considered he shall be asked to leave the room while the financial consideration of his application is under discussion. CARRIED.

(ii) Assessment of applications Feb 1948

DR. COLLIP said that it had been decided in the Advisory Committee on Medical Research to submit copies of all applications for grants-in-aid to the members prior to the meeting at which such applications were to be considered. He suggested that the Associate Committee on Dental Research might follow the same procedure.

DR. FERGUSON said that this might mean that applications which were late would not be considered. He was not in favour of rigid rules in regard to applications because in many cases applicants spent considerable time in the consideration of possible projects before

filing applications for grants-in-aid and that, as most of the applicants had heavy teaching programmes, they were frequently delayed in the completion of their application forms. He thought that such applicants should not be discouraged by the Committee. He doubted that members would have time to read all the applications received in advance of a meeting.

DR. CHARRON said that any applications which were received too late to be summarized could always be considered at a later meeting of the Committee or dealt with by the Executive if the subject was urgent.

DR. STIBBS thought that the members should be sufficiently interested in the work of the Committee to study any applications that were sent to them.

THE CHAIRMAN summing up this discussion drew attention of the members to the fact that, in the paragraph marked "Procedure in making an application" in the little booklet issued by the Committee, it was stated that "In general, applications should be submitted by 1 February in each year so that the budget of the Committee can be set up to take care of the projects which are accepted. Consideration of applications received at other times may have to be deferred". He said that this subject had been considered at the Second Executive meeting and that the date of 1 February for the filing of applications had been confirmed. The Executive had further recommended that the Chairman of the Committee be authorized to select suitable referees to report on all applications. Under this procedure the Secretary would send to the Chairman copies of all applications received prior to 1 February in each year and it would be his duty as Chairman to have these applications reviewed and assessed by competent referees.

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It was AGREED that this procedure be followed.

(iii) Travel by grantees in connection with their projects.

THE CHAIRMAN said that in the examination of several applications for grants-in-aid it had been noted that items were sometimes included to cover travel by grantees, as for example in visiting other research workers in connection with their projects or in the collection of material. He said that it was a general rule that grants-in-aid were not made to cover travel expenses and he thought such requirements could be met if the grantees filed with the Committee, applications for permission to travel as each occasion arose. Each application could then be dealt with on its merits.

The view was expressed that if applicants had to wait for decision of the Committee in each case it might be detrimental to the progress of the research and it was suggested that authority might be given to the Chairman to deal with travel applications.

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1948

It was MOVED by Dr. Charron and SECONDED by Col. Wansbrough:

That the Chairman of the Committee be authorized to deal with applications for permission to travel filed by holders of grants-in-aid when in his opinion such travel is essential to the conduct of the research project; and that expenses thus incurred when reported on the prescribed travel forms and supported by the necessary vouchers, be paid out of the Committee Travel Grant.

CARRIED.

9. Applications for Renewal of Grants for 1947-48

DR 1 Dr. J. J. Rae An investigation of the chemical mechanism involved in dental caries.

It was noted in discussion of this application that special apparatus is listed at \$500. and special books at \$50. The Secretary was directed to write to Dr. Rae for further information on these two items and to point out that it is not usual to permit the purchase of books under a grant-in-aid. Purchase of special apparatus can only be authorized when it is of a kind that a university might not be expected to have or to require in connection with the general operation of its research laboratory.

APPROVED. \$1,000.

DR 2 Dr. G.H.W. Lucas Chemical study of nitrous oxide for dental anaesthesia.

THE CHAIRMAN said that the application filed by Dr. Lucas had been for \$2,400. including an item of \$500. for travel but that in accordance with usual practice this item had been struck out. He reminded the members that earlier in the meeting it had been decided that when grantees find it necessary to travel in connection with their projects they should make application to the Chairman who may, in his discretion, approve of such expenses being charged to the Committee Travel Account.

APPROVED. \$1,900.

DR 3 Dr. H.K. Box A study of micro-organisms found in periodontal pockets and dental caries, as revealed by the electron microscope.

DR. BOX said that no funds had been drawn under this grant during the present year owing to the lack of an electron microscope with which to do the work. The renewal of the application was requested as the instrument will be available shortly. The funds will be spent on electron microscope photographs.

APPROVED. \$ 500.

DR 4 Dr. H. K. Box An investigation of packing materials in the treatment of periodontal disease.

DR. FERGUSON said he thought information should be given on the application regarding the method of attack to be followed in carrying out the project.

APPROVED. \$2,200.

DR 5 Dr. A.E.R. Westman Research on denture base materials and Major Twible and denture preparation, \$6100.

(2) There was considerable discussion on this application (formerly held in the name of Major Twible.) It was AGREED that the Chairman should discuss this application with the Ontario Research Foundation and report back to the Executive.

DR 6 Col. E.M. Wansbrough Effects of altitude change on oral tissues.

THE CHAIRMAN reminded the Committee that this application is now being filed in the name of Col. Wansbrough as Dr. Coons is no longer connected with the Royal Canadian Dental Corps.

COL. WANSBROUGH said that as the work would be done under the Royal Canadian Dental Corps no grant would be required from the Committee.

PROJECT APPROVED.

DR 7 Dr. J.S. Bagnall Critical survey of the literature on dental caries.

APPROVED. \$ 225.

DR 8 (COMPLETED)

DR 9 Drs. O.J. Walker and H.R. MacLean An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

APPROVED. \$1,000.

DR 10 Dr. G. M. Macdonald Facial Prostheses

THE CHAIRMAN said that the initial grant under this project had been made in October 1946 and that it was expected that a further application would be received for the continuance of the project.

(3) It was AGREED to encumber \$800. for this project for 1947-48 pending receipt of an application and its approval by the Executive.

DR 11 Dr. R. J. Godfrey An anatomical, histological and physiological study of the role of the condyle in mastication.

THE CHAIRMAN said that in addition to the \$2850. asked for in the application there had been an item of \$300. for travel which had been struck out according to the Committee rule.

It was noted that the application included an item of "Miscellaneous equipment \$300." The Secretary was directed to ask for particulars of this item.

DR. GARVIN said that Dr. Moses had published a paper in the Journal of the Canadian Dental Association which might be reviewed in connection with this application.

THE CHAIRMAN suggested that the application might be reviewed before the grant is made.

(4) It was AGREED to encumber \$2850. pending review of the application and its approval by the Executive.

DR 12 Dr. A.E.R. Westman Investigation of cements for methacrylate inlays, \$2550.

(5) It was AGREED that this application from the Ontario Research Foundation should also be discussed by the Chairman with the Officers of the Foundation and reported upon to the Executive. The Executive was authorized to deal with this application when the additional information has been secured.

10. New Applications, 1947-48

(1) Dr. M. Doreen Smith A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

DR. THOMSON was rather skeptical regarding the possibilities of a microbiological method for the analysis of fluorine.

DR. COLLIP thought that this project might be considered by the Assisted Researches Committee of the National Research Council rather than by the Dental Research Committee.

DR. FERGUSON was of the opinion that the development of a new method for the determination of fluorine might be very useful. He thought that the Dental Research Committee should encourage grantees in the biochemical field and other sciences to interest themselves in problems having a bearing on dentistry.

On a MOTION by Dr. Ferguson SECONDED by Dr. Linghorne, this application to be known as DR 13 was APPROVED. \$1050.

- (ii) Dr. M. Doreen Smith Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

THE CHAIRMAN said that the Executive had suggested it might be useful for him to discuss this project with Dr. Smith and to point out that the programme of work on fluorine content of food samples was of greater interest to the Committee than the study of methods of analysis.

On a MOTION by Dr. Garvin SECONDED by Dr. Coons, this application to be known as DR 14 was APPROVED. \$1125.

- (iii) Dr. Norma Ford A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches.
Walker

On a MOTION by Dr. Ferguson SECONDED by Dr. Linghorne, this application to be known as DR 15 was APPROVED. \$3,000. ✓

- (iv) Dr. C. H. Best The development of culture technique for certain fungus-like organisms found in periodontal disease.

This is a renewal of a grant for work in continuance of the bacteriological study initiated under DR 4 last year.

On a MOTION by Dr. Stibbs SECONDED by Dr. MacLean, this application to be known as DR 16 was APPROVED. \$1100.

(v) Dr. R. F. Shaner An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth.

On a MOTION by Dr. Sibbs and SECONDED by Col. Wansbrough, this application to be known as DR 17 was APPROVED. \$1000.

(vi) Dr. H.K. Box Experimental production of dental caries.

On a MOTION by Dr. Charron SECONDED by Dr. Ferguson this application to be known as DR 18 was APPROVED. \$1350.

(vii) Dr. E.A. Sellers Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry.

DR. FERGUSON explained that although this application was from a medical doctor the subject was of direct dental interest.

On a MOTION by Dr. Charron SECONDED by Dr. Coons, this application to be known as DR 19 was APPROVED. \$1300.

11. Summary of Action Taken on Applications

<u>Item</u>	<u>No.</u>	<u>Total Amount</u>
		\$
Renewals		
Granted	6	6825.
Encumbered	2	3650.
New Applications		
Granted	<u>7</u>	<u>9925.</u>
TOTAL	<u>15</u>	<u>20,400.</u>
Held	2	8,650.

(as noted in Minute 7(ii) provision was made for Dental Travel in the amount of \$2,000. and for Dental Contingencies, \$500.)

12. Publicity Regarding Projects

DR. COONS said that following the publication of Dr. Garvin's editorial on the work of the Committee he had received several requests for information regarding the various projects being carried on but he did not know whether it was permissible to discuss the programme of the Committee.

DR. FERGUSON said that he thought it would be in order for study groups to invite a grantee to discuss his project informally.

THE CHAIRMAN said that discussions regarding research projects being carried on under the Committee's auspices might often be helpful to the Committee. He recalled that Dr. Ferguson had said one of the applications dealt with at this Meeting had arisen just out of such a discussion.

13. Retirement of Members

THE CHAIRMAN drew attention to the fact that five members of the Committee complete their term of office on 31 March, 1947. These members are:

Dr. H. R. MacLean,
Dr. M. H. Garvin,
Dr. A. R. Gordon,
Dr. C. H. Best,
Dr. D. L. Thomson.

He said that these members having served only one term would all be eligible for reappointment.

It was MOVED by Dr. Stibbs and SECONDED by Col. Wansbrough:

That the Associate Committee on Dental Research recommend to the National Research Council of Canada that the following members of the Committee be reappointed for a further term of three years from 1 April 1947:

Dr. H. R. MacLean,
Dr. M. H. Garvin,
Dr. A. R. Gordon,
Dr. C. H. Best,
Dr. D. L. Thomson.

CARRIED.

14. Establishment of Fellowships

THE CHAIRMAN suggested that consideration be given to the desirability of establishing fellowships under the Associate Committee on Dental Research for the purpose of further promoting post-graduate work in dental research. After some discussion it was AGREED to refer this subject to the Executive for further consideration and it was requested that a report be brought in at the next meeting of the Committee.

6

15. Draft By-law Respecting Committees

THE SECRETARY said that a draft by-law respecting National Research Council Committees had been prepared and referred to the Review Committee of the Council for consideration at its next meeting. Copies had been sent to all Council Committees also for consideration and any comments their members might care to make.

THE CHAIRMAN suggested and it was AGREED that the draft by-law be included as an Appendix to the proceedings of this Meeting in order that the members may have an opportunity of studying it and offering any suggestions that they may wish to put forward for consideration by Council. This document appears in
APPENDIX "Q"

16. Date of Next Meeting

THE CHAIRMAN said that the autumn meeting in 1946 had been arranged to coincide with the meeting of the Montreal Dental Association which is usually held in October and he suggested that the same procedure be followed this year. The next meeting will be held at the call of the Chair.

The Meeting adjourned at 4:30 p.m.

APPENDIX "A"

FINAL REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

1946-47.

Subject: The Chemical Mechanism of Dental Caries.

Authors: J.J. Rae, C.T. Clegg and Miss M. I. Davies.

Project No. DR. 1

SUMMARY

Purpose: To study the chemical mechanisms underlying tooth decay.

Scope and Conclusions:

- (a) The protective effect of fluorine may be due to precipitation of calcium fluoride. Other materials such as barium nitrate, ammonium oxalate, lead nitrate and silver fluoride also protect teeth from acid decalcification.
- (b) Salivas, Casec solutions and inorganic salt solutions when shaken with calcium phosphate show a decrease in calcium and an increase in phosphate which may be due to a change in pH of the solution. CaO and P_2O_5 in calcium phosphates seem to dissolve and precipitate independently.
- (c) An investigation of the relationship between organic phosphate and immunity to dental caries is being carried out.

Date: February 12/47

APPENDIX "A"

INTERIM REPORT NO. 3 ON PROJECT NO. DR 1

Subject: The Chemical Mechanism of Dental Caries

Period

Covered: September 15, 1946 - February 1, 1947.

Authors: J. J. Rae, Ph.D., Charles T. Clegg, Phm.B., and
Muriel I. Davies, IV. Chem.

Institution:

Department of Chemistry,
University of Toronto.

A. Effect of Shaking Salivas and Inorganic Solutions with Calcium Phosphates

As mentioned in our last report (DR 1, No.2), Karshan had reported that a difference exists between salivas from caries-free and caries-active individuals. When their salivas were shaken with calcium phosphate the decrease in the phosphate and the decrease in calcium differed markedly with stimulated salivas between the two groups. In our experiments we observed increases in phosphate and decreases in calcium on shaking salivas with tri-calcium phosphate.

The same effect, i.e. a decrease in calcium and an increase in phosphate was observed on shaking inorganic salts and Mead's Casec solutions as described in our last report.

There are two possible explanations for our results:-

(1) A calcium phosphate with a Ca/P ratio greater than the Ca/P ratio of the solution (0.5) was being precipitated and at the same time a material which produces a solution with a Ca/P ratio of about 0.5 was being dissolved.

When mixtures with the following Ca/P ratios = 1.29, 1.59, 1.76, and 1.93 were shaken with $\text{Ca}(\text{NO}_3)_2 - \text{Na}_3\text{PO}_4$ solution containing 8.42 mg.% Ca and 13.1 mg.% P (Ca/P ratio = 0.644), the calcium decreased in all the final supernatants by an average of 60%, but there was no apparent relation between the Ca/P ratio and the % Ca removed. The phosphate concentration increased 79% on an average, except in the case of the powder with the Ca/P ratio of 1.29, where there was a slight lowering of the I.P.

"A-2"

These results present no evidence for the suggestion that a salt with a Ca/P ratio greater than that of the solution was being precipitated, but do seem to indicate that while phosphate was dissolving a calcium salt was being precipitated.

(2) (a) Another possible explanation is that the solubility of calcium phosphate varies with pH, and if the solubility of the CaO and P₂O₅ components of the phosphate vary independently, this would also explain the results obtained. In an experiment to test this, a series of buffered solutions were shaken with Ca₃(PO₄)₂ and CaHPO₄ and the results obtained were similar in each case, i.e. the Ca concentration dropped continuously with increasing pH, whereas the I.P. concentration dropped to a minimum and then rose. The results are shown in Table I.

TABLE I

The Effect of Shaking Solutions of Different pH's
with Tri-Calcium Phosphate and Di-Calcium Phosphate

Tri-Calc. Phosphate (Ca ₃ PO ₄)					Di-Calc. Phosphate (CaHPO ₄)				
pH		Ca Mg. %	P Mg. %	Ca/P	pH		Ca Mg. %	P Mg. %	Ca/P
Initial	Final				Initial	Final			
4.50	5.50	33.3	19.6	1.70	4.60	6.47	38.0	26.0	1.46
5.05	5.28	16.6	13.9	1.19	5.24	6.72	19.5	13.0	1.50
5.70	5.53	9.6	10.6	0.91	5.90	7.10	7.6	7.0	1.08
7.48	6.59	1.1	12.3	0.089	7.46	7.62	3.6	6.2	0.61
8.40	7.15	0.55	13.9	0.004	8.22	7.72	1.6	15.7	0.09

These results suggest that a saliva shaken with either of these salts at pH of 7 would show a decrease in calcium and an increase in phosphate whereas at a lower pH both calcium and phosphate would show an increase.

(b) Inorganic salt solutions shaken with Ca₃(PO₄)₂ at varying pH's show that at a final pH of 4.95 the Ca rose from 8 - 41.1 mg.% whereas the P rose from 16 - 36 mg.% but at a final pH of 7.60 the Ca dropped from 8 to 0.8 and P rose from 16.0 - 27.0 mg.%.

"A-3"

The results are tabulated in Table II.

TABLE II

The Effect of pH on Shaking Inorganic Solutions
with Calcium Phosphate

pH		Calcium mg. %		mg. %	
Initial	Final	Initial	Final	Initial	Final
4.52	4.95	8.04	41.1	16.5	36.0
5.20	5.25	8.04	24.4	16.5	34.4
6.65	5.78	8.04	9.26	16.5	30.0
7.40	6.32	8.04	2.19	16.5	25.5
8.50	7.60	8.04	0.84	16.5	27.0

These results show that the results obtained with inorganic salt solutions are also dependent upon the pH, and that at a low pH both Ca and PO_4 increase, but at pH's above neutrality the Ca drops and the PO_4 increases.

(c) A preliminary experiment with salivas at varying pH indicates analogous results, i.e. at a low pH (5.22) the Ca rose from 6-18 mg.% and the PO_4 rose from 18-30 mg.%, but at a slightly higher pH (5.25) the Ca dropped from 6- 3.16 mg.% and the PO_4 rose from 18-31.5% when the saliva was shaken with calcium phosphate.

The significance of these results is that experiments involving shaking of salivas with calcium phosphate should be done in well-buffered solutions in which the pH is carefully controlled.

The differences observed by Karshan between caries-free and caries-active individuals may be due entirely to the fact that the caries-free salivas are better buffers and so the pH is kept nearer neutrality and the Ca would decrease more on shaking with calcium phosphate.

B. Effect of Fluorides and Oxalates in Tooth Powders on the Protective Effect of such Powders on Teeth

In view of the protective effect of fluorides and oxalates shown in Report No. 1, it was considered advisable to study the effect of fluorides and oxalates when incorporated in tooth powders. Since soluble salts of fluorides and oxalates are poisonous, the relatively insoluble CaF_2 and Mg oxalate were used. A tooth powder was prepared having the following formula:

BASIC FORMULA

Magnesium Oxalate	- 1 gm.
Calcium fluoride	- 1 gm.
Calcium triphosphate	- 62.3 gm.
Magnesium carbonate	- 2 gm.
Sodium bicarbonate	- 22 gm.
Sodium chloride	- 5 gm.
Castile soap powder	- 6 gm.
Saccharin	- 0.2 gm.
Oil peppermint	- 0.5 gm.

Four powders were made with the following differences:

1. Full formula
2. Without magnesium oxalate
3. Without CaF_2
4. Neither CaF_2 nor magnesium oxalate

These powders were tested by shaking with teeth and lactic acid for 1 hour and examining the teeth after being in the solution for 24 hours.

When 50 mg. of the powder was added all the teeth decalcified, due to the fact that the concentration of the fluoride and oxalate was too low. Earlier experiments have shown that 5 mg. fluorine per 10 c.c., or 10 mg. oxalate per 10 c.c. (50 mg. magnesium oxalate) are needed for protective effect. With larger amounts (300 mg.) of the powder, none of the teeth was decalcified due probably to the protective effect produced by $\text{Ca}_3(\text{PO}_4)_2$.

Further experiments showed that CaF_2 and magnesium oxalate when used alone had no protective effect. This is probably due to their insolubility. There is not enough fluoride or oxalate going into solution to produce the expected protective effect. The solubility of CaF_2 in 1% lactic acid was found to be 2.23 mg. per 10 c.c. and in 5% lactic acid = 3.06 mg. per 10 c.c. The solubility of magnesium oxalate in 1% lactic is 26.6 mg. per 10 c.c. and the solubility of magnesium oxalate in 5% lactic is 48.4 per 10 c.c. Even in 5% lactic acid the concentrations of F and C_2O_4 obtained are below those needed to observe the protective effect.

The slightly more soluble barium fluoride did exert a protective effect when added to tooth powder No. 4 and to Squibb's tooth powder.

These results would indicate that the beneficial effect of the incorporation of protective agents in a calcium phosphate tooth powder is difficult to demonstrate. Probably the addition of sodium fluoride and oxalate in small amounts would be beneficial,

but animal experiments should be carried out on the toxicity of these materials if they were to be applied indiscriminately by the public at large.

C. The Chemical Composition of Saliva and its Relationship to Dental Caries. (Miss Davies)

1. Investigation of the forms of Calcium and Phosphorus in Saliva

(I) Phosphorus (T.P. Total phosphorus, I.P. Inorganic Phosphorus, O.P. Organic Phosphorus.)

The results of experiments led to the conclusion that 10 to 15% of the phosphorus in saliva was organic. There was no appreciable amount of phosphorus in the precipitate from the trichloroacetic acid (TCA) treatment.

(II) Calcium

These analyses gave results for the inorganic calcium (ICa) which were the same as the TCA results within experimental error. This led to the conclusion that there was either no organic calcium or, if organic calcium was present, it was very loosely bound.

(III) Shaking salivas, Casec, and Inorganic Salt Solutions with BaSO₄ and Ca₃(PO₄)₂.

(a) Saliva. In view of the fact that Karshan had found that on shaking saliva with Ca₃(PO₄)₂ the calcium and phosphorus content was lowered, the lowering being greater in saliva from persons immune to caries, this was investigated further in order to find out if possible what forms of calcium and phosphorus were adsorbed or precipitated by Ca₃(PO₄)₂.

Since Ca₃(PO₄)₂ contains both calcium and phosphorus the decrease in the amount of calcium or phosphorus would not be a true measure of adsorption or precipitation due to the fact that calcium phosphate might also be dissolving. Analogous experiments were therefore carried out shaking with BaSO₄ instead of Ca₃(PO₄)₂.

Before proceeding with these experiments a series of experiments was carried out varying the amounts of BaSO₄ and Ca₃(PO₄)₂ respectively and the length of time of shaking. From these experiments it was concluded that shaking for half an hour with 1 gram of Ca₃(PO₄)₂ or BaSO₄ to 5 ml. of saliva was sufficient for complete adsorption or precipitation of the calcium of phosphorus which could be adsorbed or precipitated by shaking with these salts.

After shaking with $\text{Ca}_3(\text{PO}_4)_2$ the loss in calcium was about 35% but the phosphorus content was increased threefold. After shaking with BaSO_4 both the IP and TP went down; the OP seemed to be completely adsorbed. The loss in calcium after shaking with BaSO_4 was about 80%.

(b) Casec. The Mead's Casec solution used in these experiments contained 0.30 grams of Casec were 100 ml. of solution for calcium experiments (about 5.4 mg.% calcium) and 1.0 gram of Casec per 100 ml. of solution for the phosphorus experiments (about 7.7 mg.% OP and 0.5 mg.% IP).

After shaking with $\text{Ca}_3(\text{PO}_4)_2$ there was a 50% gain in calcium and a large percentage gain in phosphorus. This was probably due to the fact that Casec solution was unsaturated with respect to $\text{Ca}_3(\text{PO}_4)_2$.

After shaking with BaSO_4 there was no loss of calcium and a 30% loss of phosphorus. The loss of phosphorus was probably due to adsorption.

(c) Inorganic Solution

The inorganic solution had approximately the composition of saliva. It contained:

P_2O_5	41.5 mg. %
K	100 mg. %
Na	23 mg. %
CaO	10.5 mg. %
MgO	0.34 mg. %
SO_4	14.0 mg. %
Cl	40 mg. %

The pH of the inorganic solution was adjusted to 4.21 and 7.25 as desired.

(i) pH 4.21: On shaking with $\text{Ca}_3(\text{PO}_4)_2$ both the calcium and phosphorus gained 100%. This was probably due to the fact that the solution at this pH was unsaturated with respect to $\text{Ca}_3(\text{PO}_4)_2$.

After shaking with BaSO_4 there was no change in calcium but a 20% loss of phosphorus.

(ii) pH 7.25: After shaking with $\text{Ca}_3(\text{PO}_4)_2$ there was a 20% decrease in calcium and a great gain in phosphorus.

After shaking with BaSO_4 there was a 30% decrease in phosphorus and a 50% decrease in calcium.

These results indicate that adsorption of calcium and phosphorus was greater at a higher pH. This may be due to the fact that the solution at pH 7.25 was more nearly saturated with calcium and phosphate.

CONCLUSIONS

Shaking with BaSO_4 causes an adsorption or precipitation of inorganic calcium and phosphorus. It also seems to cause precipitation of OP in Casec and saliva.

(IV) Effect of Ammonium Sulphate on Casec Solution, Saliva and Inorganic Solution of the same Inorganic Composition as Saliva.

A series of experiments was carried out on the effect of saturating these solutions with $(\text{NH}_4)_2\text{SO}_4$. The purpose of these experiments was to obtain if possible an estimate of the protein bound calcium and phosphorus in saliva.

The results obtained are indicated in the following table:

TABLE I

Effect of Saturating with $(\text{NH}_4)_2\text{SO}_4$

	TP mg. %		I. Ca mg. %	
	Before	After	Before	After
Saliva	17	12.8	5.8	3.6
Casec solution	7.7	1.4	5.7	5.7
Inorganic Solution	-	-	7.34	2.87

CONCLUSIONS

Saturating with $(\text{NH}_4)_2\text{SO}_4$ precipitated 28% of the total phosphate and 38% of the calcium from saliva, 82% of TP and none of the calcium from Casec solution, and 67% of the calcium from an inorganic solution. The lowering of the calcium in the inorganic salt solution may be explained by its precipitation as CaSO_4 . The fact that the calcium in Casec solution was not lowered may be due to the fact that almost all of the calcium is protein bound.

(V) Precipitation of the Protein in Saliva and Casec Solution at Their Isoelectric Points

At the isoelectric point pH 3.30, 30% of the calcium and 7.3% of the total phosphate was precipitated from saliva. At the isoelectric point of Casec solution pH 4.7, 65% of the calcium and 80% OP was precipitated.

This seems to indicate the presence of protein bound calcium and phosphate in both Casec and saliva.

(VI) Investigation of Improved Methods for the Determination of Phosphorus in Saliva

Owing to the fact that in previous experiments the values obtained for total phosphorus were often lower than those obtained for IP a series of experiments were carried out in order to find out whether the error was caused by high IP values or low TP values.

(i) Total Phosphorus

Experiments were carried out on salts of known OP. Also a standard KH_2PO_4 solution was digested for the same length of time with 60% HClO_4 , and the results obtained with and without digesting were compared.

Results of these experiments indicated that the TP results were satisfactory.

(ii) Inorganic Phosphorus

In analysing saliva for IP the protein had previously been precipitated by adding unequal volume of 10% TCA. After standing for 20 minutes the solution was centrifuged and the liquid was decanted off and filtered through a Whatman 42 filter paper. This gave a solution which was almost clear. Filtering through celite gave a clear solution. However a precipitate formed when the ammonium molybdate was added in the analysis for phosphorus by King's method, thus causing higher lumetron readings. Filtering off this precipitate before addition of the aminonaphthyl sulphonic acid reagent or after addition of the aminonaphthyl sulphonic acid reagent caused an adsorption of the phosphate compound or the blue colour thus leading to low results. This was shown by experiments in which an inorganic solution was filtered at this stage in the analysis.

Since ammonium phosphomolybdate is a good protein precipitant it was thought that this precipitate was a protein not precipitated by the TCA. Various methods of precipitating the protein were tried, for example, varying the concentration of TCA, using alcohol and TCA combined, 95% alcohol, alcohol and ether combined, alcohol and potassium acetate combined, alcohol and lead acetate combined, tannic acid and the Brücke reagent. None of these methods gave satisfactory results. Some precipitated all of the protein satisfactorily but gave colour with ammonium molybdate which interfered with the blue colour method. The other did not result in clear solutions.

CONCLUSIONS

No satisfactory method of precipitating all the protein in saliva was found. Heating the solutions during the precipitation

of the protein seemed to result in clearer solutions. The best method tried seemed to be by the use of alcohol and TCA combined as a protein precipitant; this did not give clear solutions with all salivas.

(VII) Analysis by Precipitation of the IP by Magnesia

Since no satisfactory method for the IP analysis was available, the IP was precipitated by magnesia solution at a pH of 8.8 to 9.0. Digestion of the filtrate from the magnesia treatment gave a value for the OP. The IP was obtained by difference by subtracting the OP from the TP.

Reagents Added to 10 ml. of Saliva

- 1 ml. magnesia solution containing 20 grams $MgCl_2 \cdot 6H_2O$ and 25 grams NH_4Cl per litre of solution.
- 1 ml. 0.4 N $NH_4 OH$.

The volume was made up to 15 ml. in a volumetric flask. This was shaken and after standing 10 minutes it was filtered through a Whatman 42 filter paper. 5 ml. of the filtrate were digested with 1.2 ml. 60% $HClO_4$. The solution was analysed by King's method.

The method was tested by adding known amounts of sodium glycerophosphate to saliva and to KH_2PO_4 solutions respectively.

An example of the results obtained for a solution containing KH_2PO_4 and sodium glycerophosphate is given in the table below.

TABLE II

	TP mg. %	IP mg. %	OP mg. % (difference)
Before magnesia treatment	4.05	1.93	2.12
After magnesia treatment	2.31	0	2.31

The above results do not indicate a loss of organic phosphorus by adsorption on the magnesia precipitate or by hydrolysis. The results obtained for the OP by this method are higher than those obtained before the magnesia treatment; this may be due to hydrolysis of some of the OP to IP when the IP analysis was made before the magnesia treatment.

"A-10"

The percentage error is about 5%

The effect of magnesia solution on the formation of the blue colour in the analysis by King's method was also investigated by adding various amounts of magnesia to make final solution containing 3.6 to 54 mg. % magnesium. The results of these experiments indicated that the magnesia did not interfere with the phosphorus analysis by King's method in the amounts which were used.

APPENDIX "B"

REPORT

To

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines.

Author: R. J. S. Tickle

Project No. DR 2

SUMMARY

Purpose: To compare the gas percentage delivery and percentage dial setting in anaesthetic gas machines.

Scope: Work continues on this problem which has been expedited by the receipt of a gas analyser from the Cambridge Instrument Company. Operating the machine according to instructions at first gave us irregular and unsatisfactory results. Ultimately the Company sent adequate information which enabled us to proceed with the analyses. Further difficulties were experienced which were eliminated by the installation of a constant voltage transformer. Since then results of some significance have been obtained. Two main types of machines are being tested. Type A has proved relatively inaccurate and one machine in this group delivered practically a constant percentage of oxygen between the 20% and 75% range. It was noted in general that fluctuations in pressure and dial readings occurred during the operation of machines; these fluctuations resulted in marked irregularities in percentage composition. Type B anaesthetic machines to date have given more accurate percentages.

Conclusion: It would appear that there is full justification for continuing with this problem and the testing of anaesthetic gas machines on a wide scale. At this stage, consideration should, perhaps, be given to the eventual problem of measures that may be necessary to improve the accuracy of anaesthetic gas machines.

February 17, 1947.

"B-1"

Subject - A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines.

Author - R. J. S. Tickler

Project No. DR 2

An Interim Report

Work on the above problem continues and this has been expedited by the receipt of a gas analyser from the Cambridge Instrument Company. This apparatus determines the percent by volume of oxygen in nitrous oxide by means of thermal conductivity measurement and is scaled 0-20% oxygen in nitrous oxide. The measurement of thermal conductivity is accomplished by suspending a hot spiral of platinum wire in the sample. The temperature of the wire and therefore its resistance is affected by the conductivity of the gas surrounding it. The change in resistance causes an unbalance on a Wheatstone bridge and this unbalance is measured on a continuously recording potentiometer. A series of tests were made using this oxygen recorder but the results were irregular and not satisfactory. Further information was therefore sought from the Cambridge Instrument Company and in this regard long delays were experienced. Information was seemingly refused and questions not satisfactorily answered, particularly with regard to the problem of wet or dry gases. In the meantime, testing was continued using the analyser and Hempel burette method. However, on eventual receipt of satisfactory information regarding the analyser, work was continued but results still showed some irregularity. It was then thought possible that local variations in voltage might be of significance. This was found to be the case and a constant voltage transformer placed in circuit corrected this difficulty. Figures now obtained were checked using the Hempel burette-pyrogalllic acid method and a comparison of readings on the same samples showed differences up to $\pm 0.4\%$ in the oxygen content. With this check and with the assurance of the Cambridge Instrument Company that their analyser was accurate to within $\pm 0.5\%$, work was continued on the problem in hand.

Two main types of gas machines are at present being tested. Type A - This popular type of machine has so far proved relatively inaccurate. Of the number tested so far, not more than 20% of these machines delivered within ± 2 of the oxygen dial setting readings from the 0-20% mark. Tables I to IV indicate a series of results obtained using different machines.

"B-2"

TABLE I

GAS ANALYSER

Machine A - Gas flowing at 10 mm. pressure

Indicated O ₂	5.0	10.0	15.0	20.0
percentage delivery				
Actual O ₂	8.1	16.2	20.0 ±	
percentage delivery (average)				

TABLE II

GAS ANALYSER

Machine B - Gas flowing at 5 mm. pressure

Indicated O ₂				
percentage delivery	5.0	10.0	15.0	20.0
Actual O ₂				
percentage delivery (average)	7.7	14.0	18.2	

TABLE III

GAS ANALYSER

Machine C - Gas flowing at 10 mm. pressure

Indicated O ₂				
percentage delivery	5.0	10.0	15.0	20.0
Actual O ₂				
percentage delivery (average)	2.8	8.0	11.8	17.0

"B-3"

TABLE IV

GAS ANALYSER

Machine D - Gas flowing at 5 mm. pressure.

Indicated O ₂ percentage delivery	5.0	10.0	15.0	20.0	25.0	30.0	35.0	45.0	75.0
Actual O ₂ percentage delivery	5.1	7.0	8.6	9.4	12.2	13.0	12.8	12.8	15.8

It will be noted that Machine D in Table IV delivered practically a constant percentage of oxygen between the 20% and 75% range and thus should be classified as not only mechanically defective but potentially dangerous. Previously a machine tested and mentioned in my last report, gave some 50% of the actual.

In general this type of machine seemed to have certain characteristics:-

1. The pressure at which the gas mixture was delivered varied from time to time despite maintaining a constant pressure dial setting.
2. Increases of pressure through any cause altered the oxygen percentage in the mixture. Thus an appreciable change was noted when the gas pressure was altered from 3 to 10 mm.
3. The oxygen percentage of the mixture varied according to differences in the oxygen and nitrous oxide reduced pressure gauge readings. Fluctuations, not constant in both dials, occur during inspiration and expiration with the decrease and increase of pressure within the circuit. Instructions issued with this machine state that both oxygen and nitrous oxide reduced pressure gauge readings should be equalized and lie within a certain range. However, latest type machines have dials marked in zones and are not calibrated in figures, thus making this adjustment difficult. Tests made varying the reduced pressure gauge readings, yet keeping the readings within the zones marked "operating range", resulted in up to 80% variation in oxygen content.

Type B - This type of machine, though few have been tested, has so far given relatively accurate results. No difficulty is experienced with the reduced pressure valves, which remain constant. However, the oxygen percentage gauge readings must be somewhat carefully adjusted during the flow of gas. Table V gives the results from one machine that has been tested extensively.

TABLE V
GAS ANALYSER

Rate of flow 3 gals. per minute

Indicated O ₂ percentage delivery	7.0	10.0	15.0	20.0
Actual O ₂ percentage delivery (average)	7.1	9.6	14.6	18.1

Conclusion

It would thus appear that there is full justification for continuing with this problem and the testing of anaesthetic gas machines on a wide scale. At this stage, consideration should be given to the eventual problem of measures that may be necessary to improve the accuracy of anaesthetic gas machines.

February 17, 1947.

APPENDIX "C"

INTERIM REPORT TO

THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Investigation of packing material in the treatment of periodontal disease.

Authors: H. K. Box, D.D.S., Ph.D. and W. J. Linghorne, D.D.S.

Project
No.: DR 4

PART A

As stated in the interim report presented at the fourth meeting of this committee, periodontal packing materials probably exert their therapeutic effect by means of (1) their bacteriostatic action, (2) mechanical properties and (3) beneficial effect on the soft tissues which may in part be the result of (1) and (2) but may also be due to a more direct effect of the chemicals used.

In vitro studies of the bacteriostatic properties of the various materials, singly and in combination, and in vivo studies of the bacteriostatic effect in the mouth were reported at the last meeting. The therapeutic effect of the pack on the soft tissues is being investigated; also a suitable technique for using the packing materials under varying clinical conditions.

The ultimate aim of the investigation is to develop a simplified and suitable means of treatment, and a method of prevention of the commonly occurring types of periodontal disease. In treatment the problems facing the periodontist are (1) to bring the destructive process to a halt, (2) to prevent its recurrence; and (3) to repair the damage produced in the bone and soft tissues of the periodontium.

The mechanism of repair uncomplicated by disease is being studied in experimental animals. A study of the mechanism of the destructive process is also being made. It is obvious that a better knowledge of these processes is necessary to understand or to develop therapeutic procedures. The results to date are very encouraging.

Leptothrix Falciformis

PART B

Authors: H. K. Box, D.D.S., Ph.D. and D.C. O'Connell, M.S.A.

Leptothrix falciformis is a fungus-like organism found in smears from periodontal pockets. It was discovered, described and named by Theo. B. Beust in 1906. We have observed this organism in smears from pockets in cases of Necrotic Periodontitis and Vincent's Infection.

Many phases in the life cycle of this or a similar organism have been described by Beust, Aisenberg, Dean and Dean. We have observed the phases of this cycle reported by these authors and have also seen some phase variations which they have not described.

We wish to leave a description of these forms until a later date, at which time we hope to be in a better position to contribute to the study of the complex morphology of the Leptothrix falciformis.

Scythe-shaped organisms of various size have been observed for years in smears from periodontal pockets associated with Vincent's Infection and other ulcerative processes and have been known as fusi-form bacteria or fusobacteria.

Although there are numerous publications regarding the characteristics of these organisms and their presence and role in periodontal disease, it seems obvious that much further work still remains to be done. The extreme difficulty encountered in the isolation and cultivation of these organisms is responsible for confusion among the students of the fusiform bacteria.

Bacteriologists familiar with the fusiform bacillus believe that it is a separate organism and behaves as does any other bacterium. This fact was disputed by Beust; and Aisenberg agreed with him, believing that the fusiform organism, observed in pocket contents, was not a bacterium at all but merely a gonidium of a parent organism, namely the Leptothrix falciformis.

Efforts have been made to culture the Leptothrix falciformis but so far we have not been successful. However some progress towards the objective has been made.

1. Using the technique described by Slonetz and Rettger in 1933, fusiform bacteria have been cultivated from the mouths of several individuals. These organisms have been isolated and carried in pure culture and are available for future experimental studies.

2. Several workers have reported that they were unable to separate the Spirochete of Vincent's Infection and the fusiform bacteria. We have succeeded in doing so. None of our cultures of fusiform bacteria was contaminated with the spirochete.

3. We have had more success in cultivating the fusobacteria on media containing vegetable extracts than on media containing body fluids. It is hoped that a study of the nutritional elements of vegetable extracts and their influence on the growth of the fusiform bacillus can be carried out.

4. We have observed on numerous occasions that the presence or absence of other organisms such as staphylococcus, streptococcus and micrococcus has some bearing on the growth of the fusiform bacillus. This point is significant in consideration of the concept of what actually takes place so far as the organisms are concerned in the clean mouth and the dirty mouth showing evidence of periodontal disease.

5. True "cockle-burr" of fructifying head formations have not been observed in fusiform bacteria cultures but neither has any other form of multiplication been seen. Certainly, some evidence of bacilli clumping has been noticed in pure cultures and it is hoped that the application of better techniques for observing and studying the organisms will reveal the means of proliferation.

February, 1947.

NEW ASPECTS OF PERIODONTAL RESEARCH*

by HAROLD K. BOX, D.D.S., Ph.D., Research Professor of Periodontology,
Faculty of Dentistry, University of Toronto.

THE great pathologist Adam placed the causative agents of disease in two categories, namely, direct and predisposing; and, according to him, predispositions are "the result of the presence of assisting causes or of the absence of preventing properties".

Years ago in medicine, when few direct causes of disease were known, many predisposing causes were recognized. With the advent of bacteriologic research, many direct causes were discovered, as evidenced by the number of specific microorganisms brought to light. Today, concerning the aetiology of periodontal disease, predisposing causes, both general and local, have received the main attention. It must be admitted that the various attempts to show that some specific organism could be classed as a direct causative agent have not fared very well.

Among the general metabolic conditions cited in the literature are various endocrine disturbances, vitamin deficiencies, and autointoxication. Among the local predisposing factors, traumatogenic occlusion has been given a prominent place. Its localizing capacity in gingival and periodontal disease is more-or-less generally recognized today.

The precise relationship of general and local metabolic states to the

establishment of infection is not thoroughly understood, and in our want of knowledge we take shelter behind the well-known terms "lowered resistance" and "low vitality" of the tissues.

The importance of another local factor, namely, the presence of "incubation zones," should be stressed at this time. In these regions, ideal conditions, from a cultural standpoint, are provided for the development and increase in virulence of anaerobes (Box, 1930). Protection against rough usage is also furnished, which is especially needed for certain organisms to be mentioned later. In passing, the relation of the eruption of teeth should be emphasized, especially difficult eruption in the mouths of children where the gingival tissues are swollen with the establishment of "incubation zones". Inflammation of the gingival tissues of children, associated with erupting teeth, should be eliminated without delay as a preventive measure against adult periodontal disease. This conception was advanced by Becks (1929).

THE PROBLEM OF SPECIFIC INFECTION

The prevailing teaching today is that "pyorrhea" is not a specific infection. Here the term is used to denote pus-flow from the pocket; and the condition is regarded as dependent

* Presented at the National Convention of Canadian Dentists, Toronto, May 29, 1946.

entirely upon the existence of the pocket. This circumscribed viewpoint is probably correct, and serves to show how much importance has been attributed to the presence of visible suppuration. For many years, this has tended to dominate the nomenclature; the conception of the basic nature of the infectious processes concerned; and the therapy.

It must be pointed out, however, that this "pyorrhea" point of view is not adequate to explain the fundamental nature of the processes concerned in relation to certain gingival and periodontal pockets. Clinical evidence plainly teaches that many pockets of considerable depth are free from visible suppuration. This is the "dry pyorrhea" of the older practitioners, and to speak of it as "apurulent pyorrhea" obviously does not clarify matters. Both of these terms involve a contradiction. We are in agreement with Bunting and Hill (1940) that in the great majority of cases the type of infection is apurulent. It should be pointed out, in this relation, that such purulent pockets are commonly found on the enamel surface of erupting teeth of children. When suppuration does occur in this type of pocket, wherever found, we as a rule regard this event as a secondary phase of a condition that had its beginning in a primary necrotic process.

Over the years, various organisms have been imputed as direct causative agents, or playing the main role, in the production of periodontal disease. Sixty-five years ago, Arkövy mentioned a "certain fungoid formation" which he found constantly occurring in close relation to "wasting of the alveoli and the gingival margin as well as the subsequent loosening of the teeth." Black (1886) regarded his "phagedenic pericementitis" as caused by a specific form of microorganism, and suggested the probability of a

fungus causing and maintaining this condition. Later, certain spirochetes with the fusiform bacillus were thought responsible (Noguchi, 1912); then *Entamoeba buccalis* (Barrett, 1914; Bass and Johns, 1914); and *Streptococci* (Hartzell, 1919). Smith (1932) regarded "pyorrhea," using the common term, as a specific infection with a symbiotic group of anaerobic organisms common to necrotic gingivitis, viz., spirochetes, fusiform bacilli, vibrios and cocci. According to this investigator, "pyorrhea" develops on a background of general and local disturbances, and frequently both predisposing factors are present.

FUNGUS-LIKE ORGANISMS

In 1944, and again in 1945, we reported the finding, in human sections, of complex forms of organisms in the cellular debris at the base and along the wall of the pocket. They resembled certain organisms described by Beust, the Deans, and other investigators.

(a) *Leptothrix falciformis* (Beust)

Beust (1908) first described certain mouth organisms to which he gave the name *Leptothrix falciformis*. They appear to comprise a stem or stalk from which radiate many falcate or scythe-shaped spore bodies or conidia. According to Beust (1937), these conidia or asexual spores are provided with peritrichate flagella, that is to say, long, delicate filaments surround the entire organism*. He regarded these falciform spore bodies as identical with fusiform bacilli found in smears of "materia alba." He classified the *Leptothrix falciformis* with the algae-like fungi, and regarded it as pathogenic.

Aisenberg (1938) described the stem of this organism as segmented, solid and unbranched. He concluded that the falcate spores are not attached to this stem, but arise in a jelly-like

* The studies of Smith (1932) and Hine (1935) failed to demonstrate the presence of flagella on fusiform bacilli. Boe (1943) apparently was able to show that flagella are present. Recently, with the electron microscope, the writer has shown long flagella-like filaments which seem to arise from fusiform organisms obtained from periodontal pockets.

matrix which forms a sheath around it. This matrix appears to be created by certain spherical bodies which appear early on the stem. Aisenberg's findings were made from smears taken from necrotic gingivitis. (Fig. 1.)

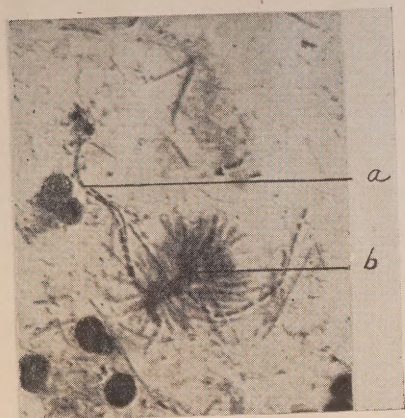


FIG. 1

Leptothrix falciformis organism in smear from deep periodontal pocket. Note the long segmented filament and fructifying head with radiating falcate spore bodies (Aisenberg), or bacillary forms.

a. filament; b. head.

(b) *Branching Plant-like Organisms*
(Dean and Dean)

Dean and Dean (1931) observed in smears from necrotic gingivitis a "dichotomous branching type of growth." Each branch comprises a central shaft made up of mycelial filaments containing granules. From this shaft, bacillary forms, including fusiforms, radiate. Cocklebur formations containing bacillary forms are invariably found near the central shaft and, at times, at the end of it. From their observations, including cultural studies, these investigators concluded that the fuso-spirochetal organisms found in the lesions of necrotic gingivitis "represent phases in the life-cycle of a higher bacterium or microscopic plant." Dean and Dean suggested that more than one genus might be involved. (Fig. 2 and Fig. 3.)



FIG. 2

Large organism, with thick stalk and radiating bacillary forms, found in smear from a deep periodontal pocket. Note similarity of this organism to the one near the base of the pocket shown in histologic section, Fig. 4.

a. stalk; b. radiating bacillary forms.



FIG. 3

Large branching organism with numerous radiating bacillary forms, found in smear from a deep periodontal pocket.

a. stalk; b. bacillary forms; c. filament.

RECENT MICROSCOPIC OBSERVATIONS

From the available evidence from various sources, we have come to regard these fungus-like formations, and associated free organisms, as a

direct causative factor in a form of periodontal disease we have termed necrotic periodontitis (Box, 1945).

The following observations concerning the pocket, the epithelial attachment, and the connective-tissue attachment seem significant:—

1. The close proximity of the parent organism to:

- (a) Regions of necrosis in pocket epithelium (Box, 1944).
- (b) Breaks in the epithelial continuity of the pocket lining (Box, 1944). The presence of these breaks was reported by the writer as early as 1921 and again in 1928.
- (c) Disorganized cementum cuticle in the pocket. The cuticle is a keratinous layer and is resistant to the action of acids and alkalis. The cuticle destruction in the pocket suggests the action of keratin-hydrolysing enzymes present in this region. It may be of interest to point out that nails and horn, when added to media, are utilized by certain fungi (Belding and Marston, 1938).

2. These organisms have been observed at the base of the pocket adjacent to necrotic epithelial attachment, and also deep in the necrotic epithelial attachment itself. Through this loss of attachment, the pocket is deepened. The deepening of the pocket proper is a phase which belongs to the epithelial attachment.

These organisms have also been noted near the pocket base where the cementum cuticle under the epithelial attachment shows marked disorganization for quite a distance apically. (Fig. 4 and Fig. 5.)

3. Certain changes have been noted under and near the base of the epithelial attachment beneath a deep pocket where the attachment is necrotic and where these complex parent organisms are present deep

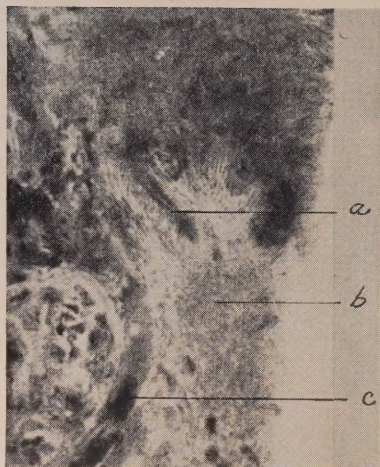


FIG. 4

Large fungus-like organism near the base of a pocket in histologic section. Note the stalk and radiating bacillary forms. The underlying homogeneous material teems with free bacillary forms.

- a. fungus-like organism; b. homogeneous material at base of pocket; c. epithelial cell.

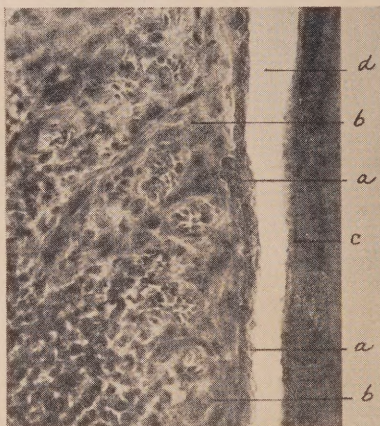


FIG. 5

Cementum cuticle close to the base of pocket shown in Fig. 4, undergoing apparent disorganization.

- a. disorganized cuticle; b. epithelium; c. cementum; d. shrinkage space.

down in the necrotic material. For some distance crownwards from its present base, the epithelial attachment lies outwards from the tooth, forming a wedge-shaped space. This space, which may extend a considerable distance crownwards, is filled with a hyaline-like material showing marked vacuolation.

In some sections, the adjacent connective-tissue fibres and cementoblasts have disappeared, with apparent transformation of the tissue into a vacuolated hyaline material. This change can be followed for some distance apically and away from the tooth to an intact fibre bundle. (Fig. 6.)

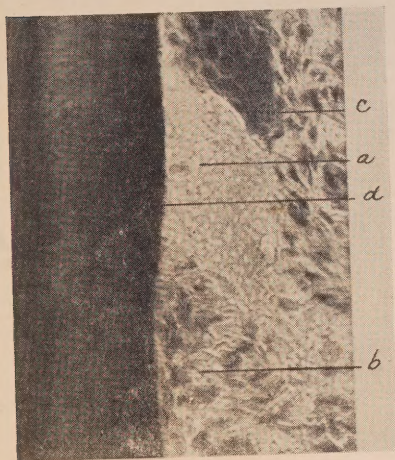


FIG. 6

Apparent transformation of connective tissue fibres near base of epithelial attachment into a vacuolated hyaline material. Note absence of cementoblasts on tooth surface in this region.

- a. vacuolated material; b. connective tissue fibres; c. base of epithelial attachment; d. cementum surface devoid of cementoblasts.

A good example of this hyaline-like change in a fibre bundle close to the base of the epithelial attachment is shown in the next illustration. Through swelling, the fibrils have

become homogenous. This has been followed by mild vacuolation. It will be noted that where the fibre bundle has been involved, few fibroblasts are present, and the area of attachment to the cementum is devoid of cementoblasts. The disorganization of the fibres seems to stand in close association with a small capillary, lacking its endothelial cells, and lying in the disintegrated fibres. (Fig. 7.)

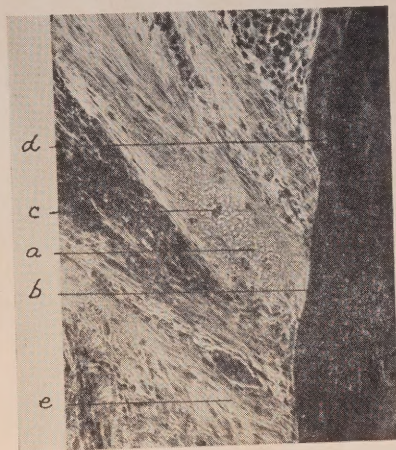


FIG. 7

Disorganization of large fibre bundle near the base of epithelial attachment. Note the fairly large region involved, and the mild vacuolation. Here the fibroblasts are few, and the area of attachment on the cementum shows no cementoblasts. Note also the small vessel minus endothelium lying in the disorganized fibres.

- a. region of hyaline-like change and vacuolation;
- b. cementum surface devoid of cementoblasts;
- c. capillary lying in disintegrated fibres;
- d. base of epithelial attachment;
- e. normal fibre bundle.

In some instances, these changes are to be observed in nearby fibre bundles and affecting them in regions considerably distant from the cementum surface to which they are attached.

Important changes** are to be observed in the deeper soft tissues

and involving, to a marked degree, the periodontal membrane for some distance apically. These changes are characterized by loss of endothelium of certain blood vessels; haemorrhage and oedema; and the presence of a coagulum of unknown nature. The red blood cells are mainly intact and the absence of infiltration of leucocytes is a striking feature. (Fig. 8 and Fig. 9.)

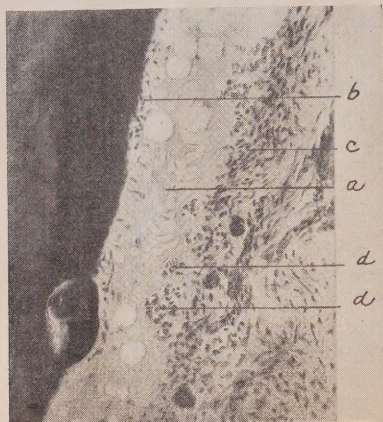


FIG. 8

Extensive changes in periodontal membrane adjacent to cementum surface. Note the vacuolated coagulum lying between attached layer of fibrous tissue on the tooth and the periodontal tissues. Note also the blood vessels devoid of endothelium, with the red cells intact.

a. vacuolated coagulum; b. fibrous tissue remnants on cementum surface; c. fibrous tissue of periodontal membrane; d. lumen of blood vessel almost filled with red blood cells.

According to our interpretation of the microscopic evidence, the agent or agents responsible for the changes appear to originate in the pocket, passing through the intercellular spaces of that part of the epithelial attachment lying close to the tooth. The findings suggest that extracellular, proteolytic enzymes are

involved***. The cuticle is attacked, and, with penetration to the collagen fibres at the base of the epithelial attachment, these fibres are disorganized.

It seems plain that the destructive changes, localized and widespread, observed in the deeper fibre bundles, and the extensive lesions in the periodontal membrane are due to the action of a fairly powerful necrotizing agent. According to our viewpoint it is probable that this agent is carried by the lymphatic vessels leading from the base of the pocket and liberated into the tissues.

Jennison (1945) showed that some species of bacteria are able to attack gelatin but are unable to digest collagen. His experiments showed that extracellular, collagen-splitting enzymes are produced by a number of bacteria. It is also known that active, proteolytic filtrates are produced by soil fungi (Waksman, 1918). Henrici (1930) has mentioned that some fungi produce an enzyme like trypsin. In their investigations of acute haemorrhagic pancreatitis, Rich and Duff (1936) carried out certain experiments on dogs where subcutaneous injections of trypsin were made. They showed that trypsin has a powerful necrotizing action on the walls of blood vessels. It is interesting, in the light of our findings, to note that red blood cells are resistant to trypsin (Wells, 1920). According to Smith (1932), powerful necrotizing enzymes are produced by the fuso-spirochetal group of organisms. These enzymes are able to destroy the elastic tissue and the muscle layer of the bronchi.

CONCLUSIONS

1. Too much emphasis has been given to the presence of visible suppuration in the pocket. This has tended to dominate our mode of thinking in periodontology, and more basic

** These changes will be described in detail and presented in bulletin form at a later date.

*** It has been shown by Burge and Burge (1914) that nascent oxygen destroys enzymes. From a periodontal standpoint, it is of interest to note that nascent or atomic oxygen therapy has been widely recommended, e.g. the Superoxol Treatment of Orban.

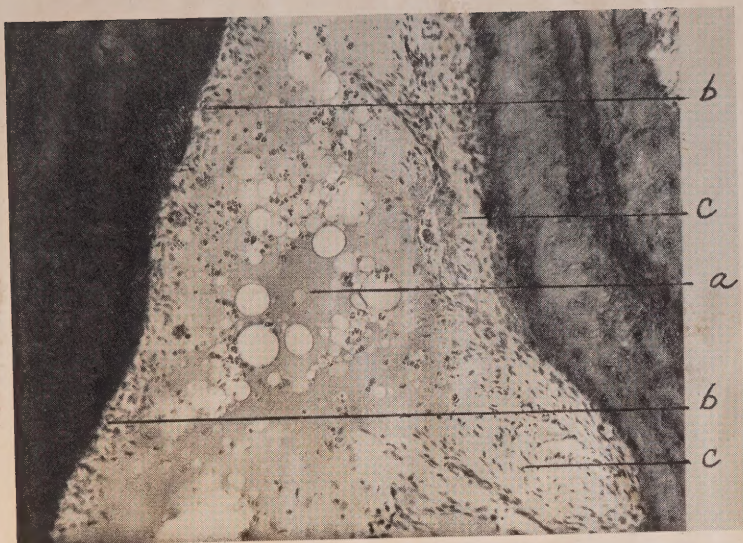


FIG. 9

Great alteration of periodontal membrane in which a widespread, homogeneous, vacuolated coagulum fuses with the fibrous tissue on the tooth and bone.

- a. homogeneous coagulum; b. fibrous tissue remnants on cementum surface; c. fibrous tissue attached to bone.

causes and processes have thus been obscured and neglected.

2. The findings would seem to warrant the tentative assumption that certain fungus-like organisms, and associated free bacillary forms, have a direct causative relationship with at least one form of periodontal disease.
3. Filterable necrotizing enzymes produced in the pocket appear to play a dominant role in the aetiology of certain fundamental periodontal lesions.

With investigations now under way in the Banting and Best Department of Medical Research, it is hoped that obscure phases of the problem will be clarified.

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APPENDIX "D"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Subject: Investigations on methyl methacrylate denture base material

Project: DR 5

Author: Douglas R. Christie, Research Fellow

SUMMARY

Purpose: Since the previous meeting in Ottawa, work on this project been directed chiefly to the development and evaluation of a practical technique for applying the principle of the "anti-porosity" procedure described at that meeting.

Scope: (a) An investigation was made of the possibility of using fusible alloys for the construction of thermoducts.

(b) With the assistance of the members of the Faculty of Dentistry at the University of Toronto, measurements were made from a collection of casts so that an indication was obtained of the range of sizes of thermoducts which would be required.

(c) Also with the assistance of the Faculty members, arrangements were made to process practical cases in the Dental College and to obtain the services of a dental technician to help with the investigations.

(d) Preliminary work has recently been started on the processing of dentures by the "anti-porosity" technique.

Conclusions: (a) It was decided that the use of fusible alloys for thermoducts in each denture case would not be practicable.

(b) Thermoducts of various dimensions were designed and were subsequently cast in bronze.

(c) Complete facilities were provided in the Dental College of the University of Toronto to process and complete practical dentures.

(d) It has been found that the lower thermoduct will have to be increased in thickness and that a method for mounting a cast containing a thermoduct on an articulator will be required. When these have been done, a comparison of the new technique and that now in use at the Dental College will be made in a series of practical cases.

February 7, 1947.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship
Report No. L-4601

Literature Survey of Available Plastics

Preface

At the suggestion of the local committee on dental research, a survey of the commercially available plastics has been made to see if any of them have potentialities as denture base materials. This survey is, for the most part, a literature study of the physical properties of plastics listed in the 1946 Modern Plastics Encyclopedia.

Comparison of Mechanical and Physical Properties

The mechanical and physical properties of materials can be of great importance in predicting their suitability in service. They are the greatest single aid outside of practical tests. Since the American Dental Association Specification No. 12 calls for different test procedures and sizes of test specimens, it is difficult to make direct comparisons of the values of the properties of commercial plastics and the specification values of denture base materials. Any comparison has to be made with the values of the plastic properties given by the Modern Plastics Encyclopedia using methyl methacrylate as a criterion. Even then, erroneous conclusions may result in some cases because of differences in test procedures and specimen sizes and also because the figures are maximum and minimum values of many types of plastic materials, some of which are special grades excelling in one particular property.

Requirements

- (1) Color and Color Stability: The denture base material must have good color possibilities and clarity so that a natural-appearing tissue-like color can be achieved and maintained.
- (2) Water Absorption: Since water absorption is closely linked with dimensional stability, the material should have low water absorption.
- (3) Curing Shrinkage: This property must be small so that accuracy of adaptation will be possible.
- (4) Thermal Expansion: Low thermal expansion is desirable to permit accuracy of fit and avoid large dimensional changes under service conditions.

- (5) Hardness: Harder materials will take and retain a high polish better than softer materials which could be easily scratched or damaged in service.
- (6) Tensile Strength: High tensile strength is desirable. This property is a useful criterion for comparing materials.
- (7) Flexural Strength: This property is analagous to the transverse strength for which a specification exists for denture base materials. Flexural strength of a material should approximate that of methyl methacrylate. Materials with much greater flexural strength than methyl methacrylate may be brittle.
- (8) Impact Strength: Other things being equal, the material with the highest impact strength should be the least liable to fracture.
- (9) Heat Distortion: The heat distortion range of the material should be above temperatures which may be encountered in service.
- (10) Density: This property is of secondary importance but a light denture is more desirable than a heavy one.

In addition to these properties there are also those of taste, odor and compatibility with mouth tissues.

It is not practical to use a molding powder, or other form of polymer material, which requires high heat and pressure to process. Nor is a thermosetting plastic desirable where the change from the monomer to the polymer is accompanied by a vigorous evolution of heat of polymerization. The present process of making dentures by using a mixture of monomeric and polymeric methyl methacrylate has been termed a "casting" technique and methyl methacrylate is classed as thermoplastic. The reaction is typically thermosetting and the technique is definitely compression molding.

The ideal plastic for making dentures would be a true thermoplastic material which could be made fluid enough at relatively low temperatures to be cast.

Possible Plastics

Most of the plastics described in the Modern Plastics Property Chart are unsuitable as denture base materials because they fail to meet one or more of the requirements listed above.

There are a few which have possibilities and the manufacturers of these materials could be contacted for further information. They are:

- (1) Cast Glyceryl Phthalates
- (2) Polystyrene
- (3) Allyl Resins (Kriston)
- (4) Cast Methyl Methacrylate

A comparison of these materials with methyl methacrylate molding material is shown in the following table.

	Methyl Methacrylate		Polystyrene		Cast Glycerol Resins		Allyl Resins Cast (Kristol)
	Molding	Cast			Phthalate		
Mold Shrinkage (in./in.)	Compression Injection .001-.005 .003-.006	--	Compression Injection .002-.005 .002-.008		3.25	--	4.0%
Tensile Strength (lb./in.2)	6,000 - 10,000	6,000-10,000	3,000-8,500		5,000-10,500		5,000-6,000
Flexural Strength "	13,000 - 19,000	10,000-15,000	4,800-19,000		9,000-15,000		8,000-10,000
Impact Strength (ft.lb./in. of Notch. 1/2 x 1/2 in. bar-Izod)	0.2 - 0.4	0.2-0.6	0.26-0.6		0.30-0.60		0.3-0.4
Hardness (Brinell No. 2,5 mm. ball, 25 Kg. Load)	18 - 20	18-20	20-30		--		--
Thermal Expansion, 10-5/°C.	8 - 9	8	6-8		5 - 12		5.45
Distortion Under Heat, °F.	145 - 190	155-200	165-190		113 - 194		140-180*up
Water Absorption (24 hr. 1/8" Thickness, %)	0.3 - 0.5	0.4	0.04-0.06		0.2 - 0.6		0.14
Effect of Sunlight	Very slight	Very Slight	Yellows slightly	Yellows	Very slight		
Clarity	Transparent	Transparent	Transparent	Transparent	Transparent		
	90-92% Transmission	88-92% Transmission	88-92% Transmission	88-92% Transmission	88-92% Transmission		
Color Possibilities	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited		
Molding Qualities	Excellent	Good	Excellent	Excellent	Unlimited		
Specific Gravity	1.16 - 1.20	1.18-1.20	1.054-1.070		1.25-1.41		1.34-1.40
Refractive Index, nd	1.49 - 1.51	1.49-1.50	1.59		1.57-1.61		1.57
Hardness (Rockwell)	M60 - M112	M60 - M100	M55 - M95		M65 - M120		M116
Compressive Strength p.s.i.	12,000-15,000	11,000-13,000	11,500-17,000		14,000-30,000		19,600

*Kristol At 66 p.s.i. fiber stress 226°F.
At 264 p.s.i. " " 190°F.

In addition, data on two very new plastic materials are available. These polymers are the polyethylenes or polythenes and polytetrafluorethylene.

Polyethylene has a low tensile strength (1425-3050 p.s.i.) does not soften below 100°C. and has a very high thermal coefficient of linear expansion ($23.7 - 46.6 \times 10^{-5}/^{\circ}\text{C}.$).

Polytetrafluorethylene is characterized by low tensile strength and extreme resistance to chemicals and heat. For the latter reason, it must be molded at temperatures of the order of 320°C. This range is out of the question for dental work.

Summary

If methyl methacrylate could be used successfully in a true casting process, a denture so made would have properties about the same as a denture made by the present technique. It is probable, however, that many new difficulties would arise, for it is almost certain that where a denture is made from a material that changes entirely from a liquid monomer to a solid polymer, the heat of reaction will be so great that it will be most difficult to control: unless it is controlled porosity will certainly occur.

Polystyrene has possibilities according to the figures in the chart. Again, the reaction of a mixture of monomer and polymer would probably be an exothermic reaction. The fact that a styrene-acrylic copolymer for use as a denture base material is (or was) available on the market, may indicate that styrene is unsatisfactory when used alone.

The glyceryl phthalate cast resins may not have adequate color stability.

Kriston, a product of the B.F. Goodrich Chemical Company, has some interesting properties and we believe a Dental and Optical Grade will be available.

The polymerization of Kriston is of course an exothermic reaction but it is processed at temperatures up to only 70°C. Furthermore, although they do not specify it, the manufacturers state that the boiling point is high. These two factors, low processing temperature and high boiling point, would seem to be advantageous over methyl methacrylate. In addition, Kriston is used in a true casting process which therefore does not require pressure. A sample of this material has been requested.

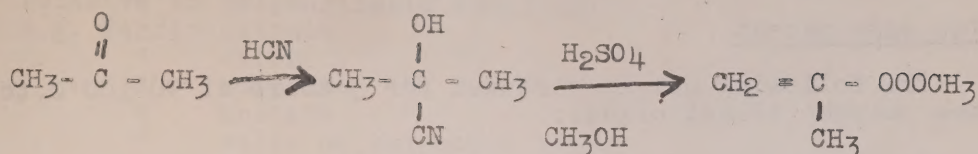
(Mr. Campbell of the Bakelite Corporation division in Toronto, is requesting information from Bakelite Corporation in Bloomfield, New Jersey, on the status of resins for denture base materials (particularly phenolics and glyptals) and will forward this information to us).

U.S. Patent No. 2,318,845 claims a very satisfactory denture base material is one containing ethyl α -methacrylate, diallyl itaconate and styrene. It is characterized by low polymerization shrinkage, low water "sorption" and a high heat distortion temperature and is molded in an identical manner as is currently used, namely, using a mixture of powder and liquid.

"E-5"

Methyl Methacrylate

Production of Monomer



Properties of Monomer (from Ind. Eng. Chem. 28 1160 (1936))

Sp. Gr. 15.6°/15.6₊ = 0.9497

Refractive Index 1.4168

B. p. °C.

760 mm.	100.3
200 mm.	61
100 mm.	46

M. p. °C. -48

Relative Viscosity 0.588

Latent Heat of Vaporization cal./g.

765 mm.	77
200 mm.	88

Sp. Heat cal./g./°C. 0.49

Heat of polymerization K.cal/mol - 13.0 ± 0.2 J.A.C.S. 67 1278
(1945)

Polymerization of Methyl Methacrylate

The monomer polymerizes readily in the presence of light, heat and catalysts, which are usually per-oxygen compounds, as benzoyl peroxide.

For example, in U.S. Patent 2,013,295

The following mixture is allowed to stand in a closed container for 4 days at 65° C.

"E-6"

monomeric methyl methacrylate	=	10 parts
methyl alcohol	=	40 "
water	=	50 "

after which the polymer is filtered out and washed.

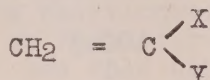
Also in the same patent

The following mix is refluxed for 3 hours at 90-100°C. to produce the polymer (Plasticized):

monomeric methyl methacrylate	=	90 parts
dibutyl phthalate	=	10 "
benzoyl peroxide	=	0.5 "

A complex catalyst system is described in U.S. Patent 2,333,633. The catalyst is a combination of an acid, a per-oxy compound and a ferric compound.

It can be used successfully for compounds having the general formula:



In general, where X is hydrogen, halogen or alkyl, and where Y is halogen, alkyl-carboxyl, alkoxy-carbonyl or acyloxy and the compound contains halogen only when X and Y both represent halogen, the reaction occurs most rapidly in aqueous emulsion.

Catalyst

- (1) Acid - Any water-soluble acid which will make the emulsion definitely acidic - preferably between pH 1.5 and 3.
e.g. Nitric acid (preferred)

Hydrochloric
Sulphuric
Benzene sulphonic
Acetic (used where hydrolysis is to be avoided)
Chloroacetic
Etc.

- (2) Peroxide - Any water-soluble peroxide or one easily emulsified in water (H₂O₂ preferred). Others may be used to react with acid to produce H₂O₂ in situ.

e.g. Benzoyl peroxide.

Sodium or potassium perborate
Peracetic acid
Sodium or barium peroxide

Use between 0.002 and 0.2 mole of per-oxygen compound per mole of polymerizable compound.

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(3) Ferric Compound - Use 0.0001 to 0.05 per cent by weight of iron relative to polymerizable compound.

e.g. Ferric nitrate
" chloride
" sulphate
" acetate
" salts of sulphonic acids
etc.

The ferric compound and peroxide are usually used in relative proportions corresponding to between 1×10^{-6} and 4×10^{-4} gram atoms of iron/mole of peroxide.

Emulsifying Agent - Any which will form stable emulsions in acid medium. e.g. egg albumen and alkali metal sulphonates of aliphatic or alkyl-aromatic hydrocarbons.

Use 0.1 per cent to 2.5 per cent of weight of H_2O .

Control of Degree of Polymerization

In U.S. Patent 2,324,935

The degree of polymerization of methyl methacrylate can be controlled by the use of 0.2% to 0.5% of chlorinated, unsaturated aliphatic compounds.

e.g. Allyl chloride

2-methyl allyl chloride
Trichloroethylene
etc.

For example: The following emulsion was heated at 70-72°C. for 1-1/2 hours:

monomeric methyl methacrylate	- 100 parts
benzoyl peroxide	- 1 part
2-methyl allyl chloride	- 0.5 "
water	- 400 "
magnesium carbonate (finely divided)	3 "

Polymerization Inhibitors

Anti-oxidants such as hydroquinone and pyrogallol are frequently added to the monomer to prevent polymerization.

In U.S. Patent 2,299,128, several inhibitors are mentioned which prevent polymerization at normal conditions but do not affect polymerization under molding conditions - i.e. at 100°C.

e.g. Benzoic acid	Pyrrole
Acetamide	Piperidine
Crotonic acid	Ammonium carbonate
Ammonium carbonate	Hexamine
Ammonia	Aldehyde ammonia

Heat of Polymerization

The polymerization of methyl methacrylate is an exothermic reaction. No mention has been found in the literature where this reaction can be controlled by chemical means.

Norrish and Brookman (Proc. Royal Soc. 171 A 147 (1939)) found that after 10-20 per cent of methyl methacrylate has polymerized the reaction becomes self-heating and is accompanied by a corresponding increase in viscosity. They propose that the rate of reaction is limited by the rate of chain growth rather than by the rate of initiation of chains. To support this theory they indicate that the energy of activation of methyl methacrylate is apparently independent of the nature of the catalyst.

There are a few references to the control of the heat of reaction by physical methods.

- (1) In U.S. Patent 2,008,719 (July 23, 1935) by G.M. Kuettel to DuPont Viscoloid:

"For producing a bubble-free product, a continuous mass comprising a liquid polymerizable acrylic or alkylacrylic acid or a homolog or derivative, is heated until the temperature of at least some portion of the mass approaches the temperature of bubble formation, then cooled until the polymerization is substantially stopped throughout the mass, and again heated and cooled separately."

- (2) Brit. Patent 395,687 (July 17, 1933) R. Hall to I.C.I.

"Articles are made by thermoplastic molding of products obtainable by known processes of polymerizing methyl methacrylate, preferably in the presence of a known polymerizing catalyst e.g. an organic peroxide, an ozonide or agent giving off O. The polymerization may be in the presence of a solvent or diluent and is preferably performed at 60-100°C., being controlled by cooling if necessary,"

- (3) U. S. Patent 2,045,660 (June 30, 1936) D. J. Leder to Du Pont Viscoloid

"For preparing a bubble-free, solid, massive product, liquid methyl methacrylate monomer is heated in a continuous mass to initiate polymerization and thereafter at least sufficient of the exothermic heat of reaction is removed to hold the temperature below that of bubble formation."

This cooling treatment is exactly what is achieved in the "anti-porosity" cycle for making dentures.

Cost of Lucitone as supplied to us

10 units of monomer ($\frac{1}{4}$ lb.)	= \$3.87
10 units of polymer ($\frac{1}{2}$ lb.)	= \$7.76

Cost/lb.

\$15.50
15.50

Properties of Methacrylate Esters

Methacrylate	Monomer			Polymer-molded Disc	
	<u>°C.</u>	<u>B.P.</u> <u>mm.</u>	<u>Density</u> <u>at 20°C.</u>	<u>Softening</u> <u>Temp. °C.</u>	<u>Description</u>
Methyl	100.3	760	0.945	125	c.h.s.
Ethyl	116.5-117	760	-	65	c.t.
n-propyl	141 - 143	765	0.921	38	c.t.f.
Isopropyl	125	760	0.888	95	c.s.
n-butyl	51 - 52	11	0.894	33	c.f.s.
Isobutyl	46- 47	13	0.884	70	c.sl.b.
Sec-butyl	53 - 57	18	0.890	62	c.sl.b.
Tert-amyl	67 - 68	20	0.887	76	c.b.
Diisopropyl carbinol	72 - 75	9	0.876	60	c.v.b.
Octyl	105	5	-	<R.T.	c.gel
Lauryl	142	4	-	<R.T.	c.viscous liq.
Phenyl	83 - 84	4	1.053	120	c.v.b.
O-cresyl	98 -103	5	1.031	106	c.v.b.
Cyclohexyl	71 - 74	5	0.959	105	c.sl.b.
p-cyclohexyl phenyl m.p.	67-68 -	-	--	145	hazy, b.v.h.
Furfuryl	80 - 82	5	1.055	78	brown, h.b.
Tetrahydrofurfuryl	81-85	4	1.039	60	trans. b.
β -chloroethyl	61 - 64	11	1.106	68	c.colorless t.
β -phenyl ethyl	110-117	5	1.018	40	c.sl.b.
β -methoxy ethyl	65 - 67	10	0.990	30	c.t.
β -ethoxy ethyl	91 - 93	35	0.996	<R.T.	clear, rubbery
Ethylene glycol mono-	85-86	5	1.079	70	white, sl.b.
" " di-	83	2	--	--	infusible,
α -methyl allyl	57- 59	15	0.921	--	insoluble " "

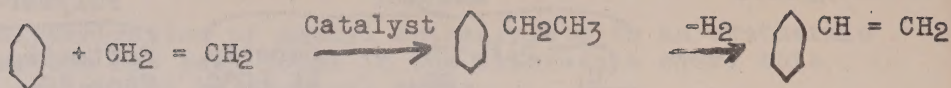
c = clear
h = hard

s = strong
t = tough

f = flexible
b = brittle

"E-10"

Styrene



Properties

	Monomer	Polymer
Specific Gravity	.9074	1.07
B. p. °C.	143° C.	depolymerizes above 300°C.
Refractive Index	1.543	1.59

Polymerization of Styrene

Styrene is also polymerized by light, heat and catalysts.

Low temperature polymerization usually produces a polymer of high molecular weight, while high temperature or catalytic polymerization results in a low molecular weight polymer. That produced by a high temperature cure is brittle.

Catalysts

Styrene can be polymerized by acidic or basic catalysts or by commonly used organic peroxides.

- (1) Acids - Unless present in small amounts, they impart a dark color.

e.g. HCl (0.5%)	Phenyl diazonium fluoborate
H ₂ SO ₄	I ₂ (but [I ⁺] in solution is inhibitor)
H ₂ CrO ₄	HOBr (partial)
SnCl ₄	Mercaptans + O ₂
AlCl ₃	SO ₂ + O ₂ (or peroxides)

- (2) Alkaline - Alkaline catalysts tend to produce low polymers and other reaction by-products.

e.g. Na	Organic bases
Na + liq. NH ₃	H ₂ O
NaHSO ₃	Heavy metal carbonyls
Alkali metal hydroxides	Tetraethyl lead
" " salts	

Inhibitors

Several compounds will inhibit the polymerization of styrene monomer.

e.g. Sulphur	Anthracene
Benzoquinone	Cresol
Hydroquinone	Pyrogallol
Trinitrobenzene	

"E-11"

Other Methods of Polymerization

Styrene can be polymerized in solution or emulsion using light, heat and/or catalysts. Hydrogen peroxide accelerates the formation of a latex in emulsion polymerization. Pressure may be required or long heating. When co-polymerization is to be carried out, it is usually done in emulsion form.

Remarks on Properties of Styrene Polymer

Styrene is very brittle in comparison with other thermoplastics. Its properties can be modified by co-polymerization with other plastics or its chemical structure can be changed. For example, chlorinated styrene has a much greater heat distortion temperature than ordinary styrene and greater chemical resistance. Some modification seems necessary if styrene is to be used in a denture base material.

Heat of Polymerization

Published values for the heat of polymerization are conflicting, as is the case with methyl methacrylate. Although the reaction is exothermic, no reference has been found where this heat has been controlled. Possibly this is because the rate of production of heat is not as great as in the case of methyl methacrylate.

Norrish and Brookman say: "With methyl methacrylate the velocities (of reaction) measured are greater than those with styrene and the reaction shows a remarkable acceleration towards the end of its course, both in the presence and absence of catalyst. This, as we have seen, is accounted for by the failure to maintain isothermal conditions as the system becomes viscous and convection is suppressed, with the resultant self-heating of the reaction. The rate of polymerization of styrene as hitherto measure is considerably less than that of methyl methacrylate and is consistent with the fact that no acceleration in the rate of polymerization of the former has been observed."

Glyceryl Phthalates

The general reaction in the formation of glyptals is a condensation of glycerol and phthalic anhydride. The chemistry is complex and a great many types of resins are available.

The physical properties previously listed cover a range of values. The chemical nature and usefulness of a resin which might be suitable for dentures may be indicated in correspondence from the Bakelite Corporation.

Kriston

Kriston is the trade name of a product of the B.F. Goodrich Chemical Company. It is merely designated as an allyl ester. The Pittsburgh Plate Glass Company also produces several allyl esters:

e.g. Diallyl phthalate
 " maleate
 " succinate
 Allyl ethyl maleate
 " lauryl fumarate
 and many others.

They are formed by the reaction of an unsaturated alcohol ester containing 2-5 C atoms.

e.g. the esters of Vinyl alcohol
 Allyl "
 Methallyl "
 Dimethyl Allyl alcohol
 Crotyl alcohol

etc.

with polyacids or polybasic acids.

A polyacid includes any compound with two esterifiable acid groups

e.g. Oxalic acid	Itaconic acid
Phthalic "	Adipic "
Succinic "	Citric "
Malic "	Tartaric "
Fumaric "	Etc.
or Boric "	Phosphoric "
Silicic "	Stannic "
Titanic "	Sulphuric "

and/or more complex acids (or polyacidic esters) wherein at least one and preferably not more than six ester linkages are present between a pair of acid groups. Many of these acids do not exist in the free state but their esters are known.

e.g. (1) $\text{HOOC} - \text{CH}_2 - \text{O} - \text{CH}_2 - \text{COOH}$

(2) Ethylene bis (acid phthalate) $\text{HOOC} \quad \text{COOC}_2\text{H}_4\text{OOC} \quad \text{COOH}$



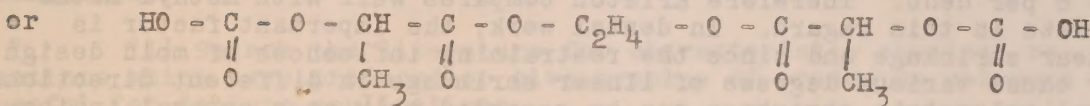
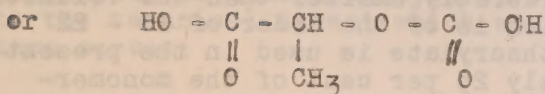
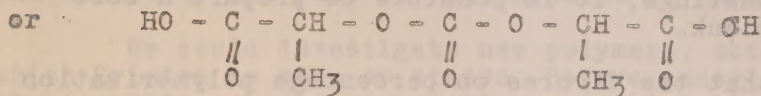
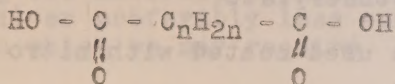
(3) Ethylene bis (acid carbonate) $\text{HO} - \text{C} - \text{O} - \text{C}_2\text{H}_4 - \text{O} - \text{C} - \text{OH}$



Other compounds which may come under this classification are polyesters of a polyhydric compound and an acid ester of a simple polybasic acid and an unsaturated alcohol.

e.g. ethylene glycol bis (allyl carbonate)
triethylene glycol bis (allyl phthalate) etc.

Many of these may be regarded as esters of the theoretical acids such as



In correspondence with the B. F. Goodrich Company we have been told that a dental (and optical) grade of Kriston would be available, and we have again requested a sample.

Kriston is supplied only as a monomer which is a pure compound with a high molecular weight and a high B.p.

Specific gravity 10°C. - 1.26
 130°C. - 1.178

Viscosity 22°C. - 50,000 centipoises
 126°C. - 12 "

Refractive Index 28°C. - 1.5483

It is soluble in ketones, esters, alcohols and aromatic hydrocarbons.

The percentage polymerization shrinkage is 3.25 to 7, depending on the degree of polymerization.

In the absence of a catalyst it can be stored for months and is stable indefinitely at 0°C.

With 1 per cent catalyst its storage life is a little more than one week at 25 - 30 °C. and at least a month at 0°C.

Preferred catalyst - benzoyl peroxide

In using Kriston, a monomer-catalyst system is prepared by heating and then the resin is cast and polymerized by heat. Curing can be done at 70°C. or higher to speed up the reaction.

The reaction is exothermic, but we have no indication of the heat of polymerization or whether it is produced at a faster or slower rate than that of methyl methacrylate.

Plaster of Paris molds can be used coated with nitro cellulose or cellulose acetate and mineral oil.

For difficult castings, it is possible to prepare a soft partially polymerized blank.

It is assumed that the figures on percentage polymerization shrinkage refer to volumetric shrinkage of the monomer. These values of from 3.25 to 7 per cent are considerably smaller than the volumetric shrinkage of methyl methacrylate which is of the order of 20 - 22 per cent. However, since methyl methacrylate is used in the present process to the extent of approximately 25 per cent of the monomer-polymer mixture, the net polymerization shrinkage is then about 5 - 6 per cent. Therefore Kriston compares well with methyl methacrylate in this regard. In dental work, the important factor is linear shrinkage and since the restraining influences of mold design may cause various degrees of linear shrinkage in different directions total volumetric shrinkage can be regarded only as a general indication of the extent to which this may occur.

Remarks

The materials which we have reviewed are commercially available products which may have possibilities as denture base materials. We have not reviewed others which are available specifically as denture base materials such as Luxene, etc., because as far as is known, none of them is an outstanding new product, in the sense that a fundamentally new material is used. Although these other denture base materials are for the most part co-polymers, they all contain methyl methacrylate as one ingredient and therefore present the same molding problems as are encountered in the present technique.

If Kriston is available as a dental grade, then its use and applications would merit investigation. However, before such work is undertaken, there are some matters of policy which should be considered.

We should find out if the B.F. Goodrich Chemical Company is itself interested in developing Kriston as a denture base material. If so, then we could probably expect little information or co-operation from them.

"E-15"

On the other hand, Goodrich may consider the dental field too small and in that case, would probably welcome our efforts along this line.

We should then learn if they will co-operate with us (a) by supplying the material without obligation at \$10.00/lb. (their quotation) or preferably less and (b) by supplying technical information which we may require.

Some member of the committee should visit Goodrich to learn the situation and find out the answers to these questions.

We could investigate new polymers, such as the allyls, of which Kriston is one, or others. Before undertaking such a programme the committee should give serious consideration to its business aspects such as time and expense, to the involved patent situation and to the technical aspect which would require a more extensive literature survey.

In such a survey, several things would have to be done and considered.

(1) Search the literature for characteristic chemical reactions which have produced or give promise of producing polymers useful for denture applications.

(2) If little or no chemical and physical data are available (as is usually the case), then such information would have to be obtained experimentally.

(3) Make an estimate of the economics of new products if they were to be applied exclusively to the dental profession. If their cost were prohibitive as applied exclusively to dentistry, consider the possibilities of their applications to other fields so that the cost could be reduced.

(4) Consider how a new product could be produced commercially, either by some established chemical company or by some other means.

We feel that after consideration of the above points, the committee would be in a better position to prescribe the limits of any literature survey or experimental work on new polymers.

December 2, 1946

APPENDIX "F"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4610 - by

D. R. Christie

Scope of This Report

A literature survey has been made of commercially available plastics having possibilities of application as denture base materials. Some information has been obtained on fusible alloys which could be used to cast thermoducts and the subject of thermoducts is considered.

Literature Survey

This survey, Report L-4601, is included with the present report.

Fusible Alloys for Thermoducts

The use of thermoducts as part of the investment in the "anti-porosity" cycle for making dentures has been shown to control the heat of polymerization of methyl methacrylate.

We suggested that, for practical purposes, these thermoducts could be made to correspond with the different impression trays which a dentist requires. The number of trays is large but thermoducts corresponding to the most commonly used ones would perhaps be sufficient.

It has also been suggested by the local committee that thermoducts could be made by casting a low-melting alloy into an artificial stone lining of a wax impression--or, in other words, a scooped-out cast.

A suitable alloy should have a melting point above 212°F. For safety it should not melt below 225°F. It should also have very little or no volume change on solidification or on cooling to room temperature. In addition, it should not have an unusually large coefficient of thermal expansion. Although data for expansion coefficients are meagre, it can be assumed that fusible alloys will expand to approximately the same extent as the bronze thermoducts which we have used successfully.

Sharp melting points exist only for pure metals, eutectic alloys and intermetallic compounds while other alloys soften and gradually liquefy over a melting range which may be appreciable in extent. However, any alloy would be suitable which does not soften below 225°F.

Binary Alloys

The metals lead and tin are the basis of most low-melting alloys and solders. The eutectic alloy contains 63 per cent tin and 37 per cent lead and melts at 358°F. The eutectic alloy of bismuth and tin melts at 275°F. while the minimum melting point of the bismuth-lead system containing 43.5 per cent lead is 257°F.

Ternary Alloys

Lead is inexpensive and tin imparts desirable mechanical features to alloys. Therefore, to obtain low melting points, it is customary to start with lead-tin alloys and add bismuth or cadmium or both. The following table shows a few eutectics.

Low-Melting Ternary Eutectics

Per Cent by Weight				Freezing
<u>Bi</u>	<u>Pb</u>	<u>Sn</u>	<u>Cd</u>	<u>Point °F</u>
51.65	40.2	--	8.15	197
52	32	16	--	205
40.7	--	27.9	31.4	217
--	32	49.8	18.2	293

The Cerro de Pasco Copper Corporation of New York produces many low-melting alloys. At our request for information about an alloy melting about 230°F, they suggested one containing 53.75 per cent Bismuth, 43.10 per cent Lead and 3.15 per cent Tin. This alloy softens at 226°F. and is molten at 246°F.

Volume Changes During and After Solidification

It has been reported that some alloys of lead-tin-bismuth show an abnormal change in volume about 170°F., probably because of the formation of a ternary compound. Such an alloy would be unsuitable for thermoducts as the sudden volume change would probably break the artificial stone cast.

We assume that this does not occur with the alloy suggested by Cerro de Pasco as no mention was made of it. They indicate that this alloy shrinks very slightly after casting but the shrinkage is offset by a progressive growth from approximately -0.0011" per inch, one hour after casting, to zero, 10 hours after casting. In 96 hours the growth is approximately 0.0012" per inch and continues to a maximum of about 0.0022" per inch in 1000 hours.

Experimental

We have made an alloy of lead and bismuth which melts at 250°F. The slight difference between this temperature and the melting point of the eutectic, 257°F., is no doubt due to small quantities of impurities.

In casting this alloy into a scooped-out artificial stone cast, bubbling occurs in the metal because of the steam produced from the water in the stone. In addition, some means must be provided to obtain a flat surface on the alloy thermoduct which contacts the bottom of the dental flask. This is accomplished in metallurgy by using a gate and a riser (See diagrams) as the metal is poured into a hollow mold.

To complete this hollow mold on the denture cast, an additional piece of equipment or cover would be necessary. It would have to contact the lower edges of the stone cast and should preferably be scooped out to some extent to allow the thermoduct to extend beyond the cast. It could be made of artificial stone, in which case, it could be broken away from the gate and riser after the thermoduct was cast. An obvious drawback to this technique is that a new cover would have to be made for each denture because (a) each denture cast would be of a different shape and (b) the cover might have to be destroyed after the alloy was poured.

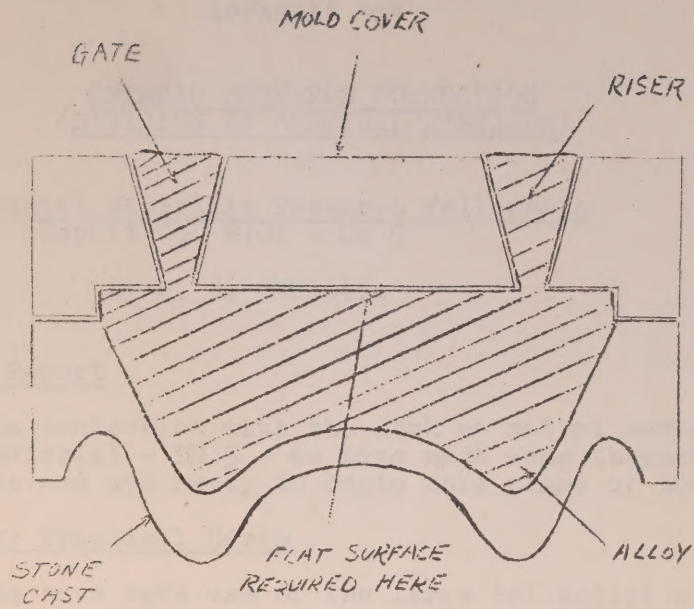
Remarks on Use of Alloys

We have indicated that the use of alloys is attended by several disadvantages, namely, the production of a surface containing bubbles and the necessity of using gates and risers to obtain a flat surface. Also, the melting and pouring of an alloy for each denture introduces another major step into the technique of making dentures. The difficulties are not serious from an experimental viewpoint but from the practical side they are appreciable.

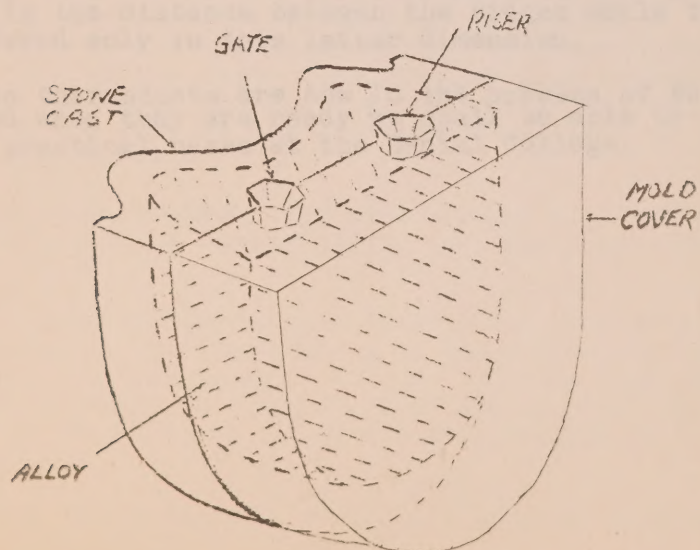
A number of ready-made thermoducts still seems to offer the easiest solution to the problem. We would like to point out that the Dental College in Toronto has a number of cast aluminum or aluminum-alloy inserts which were used to strengthen plaster casts before the stronger artificial stone became available. These inserts are almost identical in shape with the thermoducts we have in mind and were made in various sizes and shapes to fit different casts. There would seem then to be every possibility of making a variety of thermoducts and we shall give this matter our immediate attention. The Dental College has offered to let us make measurements from its large collection of casts for the purpose of getting some indication of the range of sizes of thermoducts which would be required.

December 10, 1946.

"F-4"



2 METHODS OF CASTING THERMODUCTS



APPENDIX "G"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4701 - DR 5

by D. R. Christie

Scope of This Report

In connection with the work on methyl methacrylate denture base material - DR 5 - we have made some thermoplasts for practical cases and are ready to begin this phase of the work.

Thermoplasts for Practical Cases

We have made use of the large collection of denture casts - both uppers and lowers - at the Dental College of the University of Toronto. Measurements were made of the important dimensions such as depth of vault, distance between ridges, etc. and from these a very good indication of the average dimensions and variations from the average were obtained.

With the aid of these measurements, several thermoplast models both for full upper and lower dentures were made. To be exact, four upper thermoplast models and two lowers were designed. The upper models had slight variations in the depth of the vault and in the distance between the ridges while the lower models differed only in this latter dimension.

These thermoplasts are now in the process of being cast in bronze and when they are ready we shall be able to commence work on practical cases at the Dental College.

January 13, 1947.

APPENDIX "H"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4702 - DR 5

by D. R. Christie

Scope

The processing of dentures by the "anti-porosity" technique has been begun at the Dental College, University of Toronto. Preliminary studies and the object of this research are described.

Experimental Work

We have commenced the study of the application of the "anti-porosity" technique to the making of practical dentures by processing a few test cases. The purpose was to acquaint the writer's assistant, Mr. F. Wood, with the technique, to try it out for the first time on lower dentures and to adapt it to all the steps in the process of making a denture from the impression stage to the finished product. It is proposed to make a comparison of the "anti-porosity" technique and the procedure taught at the Dental College and also to compare various separating media with tinfoil.

Preliminary Results

The work has not progressed far enough at this stage to draw any general conclusions but indications are promising. We have encountered a few minor difficulties. For instance, new castings will be required for the thermoplasts for lower dentures. When properly inserted in the casts, the present ones necessitate that the dentures be invested too far down in the dental flask with the result that the land of the investment is far from the desirable horizontal position.

We have also learned that some device will be required to fasten a cast containing a thermoplast to the mounting ring of an articulator.

It has been discovered too that it is an easy and accurate step to position the thermoplasts in the artificial stone cast if the impression is not boxed. However, it has been pointed out that boxing ensures that the periphery of the denture is preserved, so it would appear to be safer to use the boxing method of forming a cast.

A record is being kept of all procedures, difficulties and results.

February 6, 1947

REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: To study the effects of altitude, acceleration, and decelerations on oral tissues.

Author: Royal Canadian Dental Corps (Dr. D. S. Coons)

Project: DR 6

SUMMARY

Purpose: To investigate all phases of lowered pressures and temperatures including rapid changes due to acceleration and deceleration which may affect mouth tissues of flying personnel.

Scope: The study as planned included:

- (a) A review of the available literature and investigations to date.
- (b) Investigations in the low pressure chamber and in actual flight of the effects of varying pressures and temperatures on the gingivae, teeth and pulp with particular emphasis on untreated pathological conditions.
- (c) The use of service personnel as subjects in the study.
- (d) Investigations to be planned and carried out by dental officers assigned from the R.C.D.C.
- (e) Use of the facilities of the Institute of Aviation Medicine at Eglinton when required.

Conclusions:

- (a) The review of the available literature on this subject is still being carried out. In addition it was decided to review some subjects in the field of aviation medicine so that the study could be integrated with medical problems.
- (b) A dental officer--Major Purdy-- has been assigned to R.C.A.F. Station Eglinton to engage in this study, in addition to carrying out routine clinical duties.
- (c) Close contact is being maintained with projects under study at the Institute of Aviation Medicine.
- (d) It is proposed to establish a library composed of all publications dealing with this subject.
- (e) Difficulty is being experienced in obtaining trained personnel to operate the machines at the Institute of Aviation Medicine. Some phases of the project as planned cannot therefore be carried out at present. The study is being confined to phases which do not require the use of a large experimental group of personnel or demand frequent use of some of the larger items of equipment until such a time as conditions become more favorable.
- (f) The work is proceeding under the direction of D.G.D.S.
- (g) A grant in aid is not required at present.

18 February, 1947

APPENDIX "J"

Interim Report

to

Associate Committee on Dental Research
Meeting February 25th, 1947.

Subject: Investigation and critical report on dental caries research.

Author: J. Stanley Bagnall

Project No. DR 7

SUMMARY

Purpose: Critical report on dental caries research.

Scope: Up to the present some 2150 books and articles have been reviewed. Of these some 1150 have been placed in the bibliography and précis made of most of these. These, at present, run to some 1800 pages of double-spaced, letter-size notes. Balance of the articles have been placed in a supplementary bibliography. There remain, in rough figures, somewhere about 5-700 hundred more articles to be covered, of which it is likely that only a small proportion will contain matter of importance. It is hoped then to have this stage completed by early Summer. It will be appreciated that this date is still tentative. The author index is well abreast of this work. Extensive indexing of subject material is well advanced. At present bibliographies are being searched to locate articles and references which have not yet been done. The first definite stage on completion of the annotating of the articles will be to finish the index and do the necessary cross-referencing. The work will then be ready for assembling and for discussing with experts in some special fields, where this will be required.

Conclusions: In view of the above remarks, none at this stage.

Date: February 21, 1947.

APPENDIX "K"

REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

1946-47

Subject: Effects of certain chemicals on materials used in prosthetic dentistry.

Authors: Dr. O. J. Walker and Dr. H. R. MacLean

Project No. DR 2

SUMMARY

Purpose: To determine effect of cleansing agents on such materials as stainless steels, nickel-cobalt alloys and synthetic resins.

Scope: Samples of cleansing agents have been analyzed. Test pieces of such alloys as stainless steels, nickel-cobalt alloys have been obtained. Preparations are under way to carry out a series of corrosion tests on these test pieces using a series of different cleansing agents at different concentrations. The project has been held up by the fact that the time that could be devoted to it by the only research assistant available has been very limited. As a result, only a small amount of the grant has been spent. It is recommended by the grantees that the Committee continue the research for another year as arrangements can be made to employ a full time research assistant for the summer months who would also be able to give considerable time to it during the winter of 1947-48.

Date: . 19 February, 1947.

APPENDIX "L"

REPORT

to the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

1946-47

Subject: Facial Prostheses

Author: G. M. MacDonald

Project No. DR 10

I. EXPLANATORY NOTE

Due to several interruptions to my work here last year, chief of which was the switch over from Army to Department of Veterans' Affairs status of this hospital and myself, my time for experiments has been limited.

Item II of this report is a copy of instructions for using a flexible resin compound for facial prostheses, prepared for the prosthetic department of Department of Veterans' Affairs in September 1946.

This compound in use as prostheses, gives a desirable texture and color initially but lacks stability in both, therefore, I am, at present, working on a modified formula of similar materials.

In as much as my working space and present staff are wholly inadequate to undertake more than a very limited amount of this particular work, I have not applied for any part of this grant so far.

In the event that this grant can be continued for another year, I would be pleased to continue further work in the interests of the National Research Council, as conditions permit.

II. OUTLINE OF A METHOD FOR COMPOUNDING AND PROCESSING FLEXIBLE PLASTICS FOR FACIAL PROSTHESES

REQUIRED MATERIALS:

1. "Vinylite" powder, a polyvinyl chloride compound.

from: CANADIAN RESINS and CHEMICALS,
107 Craig St.,
Montreal, Que.

price: 54¢ per lb.
(in 5 lb. bags)

2. Di-butyl phthalate - liquid.

from: SHAWINIGAN CHEMICALS,
107 Craig St.,
Montreal, Que.

price: 35¢ per lb.
(in gallon tins)

3. Titanium oxide. A few ounces.

4. Coloring materials:

- a) Oil paint pigments, finely powdered.
- b) Oil paints.
- c) Laboratory stains.

5. Glass mortar and pestle.

6. A dry heat oven.

7. Dental equipment and materials for models, flasking, pressing, etc.

8. Adhesive:

Duo-liquid adhesive by J. and J.
Selix by B.D.H.

The construction of wax models and molds follows the usual dental procedure for dentures and the smaller items can be processed in the regular denture flask with clamp.

PREPARATION OF COMPOUND:

The vinylite powder and the di-butyl phthalate are mixed in a glass mortar with glass pestle.

To 60 c.c. of di-butyl phthalate add vinylite powder slowly while mixing thoroughly until as much powder as possible has been incorporated (approximately 30 gms.) to produce a smooth thick but moist mixture.

The addition of oxide (titanium or zinc) to the mixture produces density and firmness of the finished product so that the amount used should be regulated according to the degree of desired density.

In our experiments, we have been using titanium oxide and for artificial ears etc. have found that 2 or 3 grains added to 30 gms. of powder is sufficient to produce a desirable translucent depth.

The titanium oxide can be mixed into the dry vinylite powder or incorporated at the time of mixing.

Coloring is now added to the mixture until the estimated matching shade for the case in hand has been obtained. The estimation is of importance due to the partial burning out of color during the heat treatment. Some experimenting is necessary to estimate just the degree of over pigmentation which will produce the desired result.

We have used finely powdered oil paint pigments of carmine, ochre and Prussian blue mixed to produce an acceptable flesh tint. The ready mixed artists' oil paints can also be used and in some respects are more easily blended. Only small quantities of these pigments are required.

The completed mixture may be used at once or within a few days.

MOLDS:

The molds for forming and heat treating the material are constructed by the same processes and materials as those used in the dental laboratory for processing dentures.

Starting with a wax-model of the desired reproduction, this is invested in a large denture flask in the usual way.

Either plaster or stone can be used, but our preference is for stone.

The flask is separated and the wax eliminated after which the mold is dried thoroughly in the low heat oven.

When the mold is dry it is painted with a coating solution. We have used Glossy-glaze (which appears to be a collodion-like solution in acetone?) with success.

To pack, we have the mold fairly warm but not too hot to finger touch.

Fillings: The mold is first started with small portions using spatula and brushes to assure filling all parts of the mold completely without air spaces. A little vibration or jarring on the bench will help to settle the material. When the mold is filled with a slight excess the flask is quickly assembled, placed in flask clamp and completely closed under pressure.

We find that heat treating is more satisfactory in a dry heat oven. We use an electric laboratory drying oven with temperature range up to 140° C and with thermostat control.

For the smaller pieces as ears etc., we find that processing for 1 hour at 130° C is quite adequate.

The clamp with flask is placed in the hot oven as soon as packed and brought up to 130° C where it is held for 1 hour.

After heat treating the clamp may be removed from oven and allowed to cool on the bench until cool enough to handle.

By opening the flask carefully and teasing out the finished form the mold can often be re-used for duplicate forms. We have processed as many as 6 ears in one mold which is an advantage in testing a variation of coloring.

The processed form can be trimmed with scissors. Also a small amount of modifying can be done with a hot, clean wax spatula.

TINTING:

We have not as yet found a perfectly satisfactory tinting medium but have compromised on solutions (well diluted) of 3 dyes in alcohol: Sudan IV, methylene blue and Bismarck brown.

None of these dyes individually produces very true colors for the purpose but by a little mixing we have used them with some success.

The solutions are applied with small artists' brushes and can be repeated until the desired shade is obtained.

In addition to other features inherent in the dyes for tinting is the fact that they will fade out over a period of time. Therefore provision must be made for re-tinting at intervals of about 6 months.

Make-up cream and flesh tint talcum can of course be used to advance by the patient.

RETENTION OF FINISHED RESTORATION:

To date the most satisfactory adhesive we have found for these flexible plastic restoration is a latex compound which has not always been easy to locate.

Johnson and Johnson market a latex compound under the name of "DUO LIQUID ADHESIVE". In England the B.D.H. produce a similar product under the name of "SELIX".

24 September, 1946.

APPENDIX "M"

AN ANATOMICAL, HISTOLOGICAL AND PHYSIOLOGICAL STUDY OF THE ROLE OF THE CONDYLE IN MASTICATION

Project: DR 11

Grantee: Prof. R. J. Godfrey, D.D.S.

Author of
this report: Charles H. Moses

Survey of Literature

A study of the dental literature indicates that the knowledge and understanding of role which the condyle plays during masticatory function is very meager and there are many conflicting opinions. While much conjecturing has been done and much has been written in a theoretical vein there is little to indicate that these theories have been proven by actual experimentation. That the condyle is considered a very important factor in masticatory movements has been emphasized many times. Most of the conclusions have been of a clinical nature. For example -- there is still much controversy about the mechanism of mouth opening -- whether the condyle not only moves forward, but remains forward in bite opening cases. There is a school of thought which believes that the condyle moves in a definite path and therefore will influence posterior teeth patterns and alignment. Another school of thought believes that the position of the teeth in the mouth influences the temporo-mandibular joint and that alterations inside the mouth will alter the "size", shape and composition of the elements of the joint.

A series of studies are planned which it is hoped will add to the information from the standpoint of anatomy, histology and physiology.

It is proposed to use animals wherever possible although some studies of humans at hospital clinics may be utilized to add to the information on this problem and to attempt to prove certain theses.

Preliminary Experimental Procedure:

(a) A group of 12 rats from two litters were utilized. The upper and lower posterior teeth on the left side of eight of the rats were clipped off. Four of the group were left as controls. The animals were examined periodically and their general condition appeared satisfactory. After five months one of the experimental rats was sacrificed and the skull X-Rayed -- the right condyle appeared to be larger than the left. The difference was so small, however, that no great importance was attached to this finding.

One month later, the balance of the experimental animals were sacrificed. The animals were weighed at that time. While the males were heavier than the females, no evidence was present to prove that rats without posterior teeth on one side suffered to any degree from loss of weight in comparison with the control rats with a full dentition.

The heads of all the animals were placed in a 10% Formalin, or preservative solution. The heads of four experimental rats and one control rat were then prepared by de-hydration and impregnation with celloidion for histological sectioning of the condyles and related structures. Ten blocks of material were mounted for sectioning and cutting of this material is under way in order that comparative microscopic studies may be made.

(b) In order that gross macroscopic comparison could be made the balance of the rats' heads were defleshed by Mr. Hope of the Royal Ontario Museum of Zoology and X-Rays measurements and other data are now being gathered on this group of animals.

(c) The posterior teeth on the left side of three rabbits were clipped on which microscopic evidence is being sought. They are being defleshed at present.

(d) Two pigs of the same litter (7 weeks old) were purchased and placed in care of Mr. Beattie (Hamilton) with one of the pigs one side of the mouth was placed out of function. Extraction was attempted under ether anaesthetic, but the posterior teeth proved too difficult to extract and were broken off. As proper facilities were lacking at the time, this did not seem to affect the health of the pig. While it was intended to make histological sections for purposes of comparison Mr. Beattie made that method impossible by disregarding our instruction. Due to an error he kept the heads of the freshly killed pigs unpreserved for almost a week. It was then decided to deflesh them instead of making sections and to make macroscopic and radiographic studies. He repeated the same error a second time. One head is about 4 weeks older than the other. This experiment will have to be repeated.

Conclusion:

(a) Some of the dried skulls are being finished for macroscopic and radiographic examination. These will be examined grossly by means of radiograph and, if possible by calibrated measurement.

(b) Work is almost completed for the sectioning of the condylar regions. Microscopic studies are to be presently made.

January 31, 1947.

APPENDIX "N"

Ontario Research Foundation
(Division of Chemical Research)

Dental Materials Research Fellowship

Subject: To develop an improved cement for methyl methacrylate inlays.

Project: DR 12

Author: Douglas R. Christie, Research Fellow

SUMMARY

Purpose: An investigation is being made of cements for methyl methacrylate restorations with the object of developing a cement which will be more satisfactory aesthetically than the currently used zinc phosphate cements.

Scope: Several lines of investigation are being followed:

- (a) The modification of the powder and liquid components of phosphate cements to produce a more translucent material.
- (b) The investigation of synthetic resins which could possibly be polymerized by a suitable catalyst system at mouth temperatures to produce a transparent cement.
- (c) The development of a material forming a water-tight seal at mouth temperatures but plastic at higher temperatures which could be tolerated by tooth tissues.

Conclusions: To date a literature survey of the zinc phosphate cements and a few qualitative experiments have been made. We are endeavouring to obtain the services of a laboratory assistant for the experimental investigations. Monthly progress reports will be submitted to the Associate Committee.

February 7, 1947.

APPENDIX "O"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship Report No. 4701 - DR 12

by D. R. Christie

Introduction

Authorization for this project on methyl methacrylate inlay cements has been received and a literature survey has been started.

Methyl Methacrylate Inlay Cements

The currently used methacrylate inlay cement is a zinc phosphate cement. The chief objection to its use is that it is not satisfactory from an aesthetic point of view. This cement is very opaque and because of this characteristic it causes a dark line of demarcation when used to seal a satisfactory inlay to a tooth.

We were impressed with the fact that an acrylic inlay could be made to match the tooth extremely well and when merely inserted in the cavity showed no line of demarcation. This suggests that a transparent cement, if one could be found would be the answer to the problem.

We have also learned from the literature that a set zinc phosphate cement contains a considerable quantity of zinc oxide which has not reacted with the phosphoric acid. Since zinc oxide is a well-known opacifier, it is not surprising that its use produces the effect it does. Another solution to this problem would then appear to be to find some means of reducing the opacity of the cement by altering its composition.

Further consideration will be given to this problem in the immediate future.

January 13, 1947.

APPENDIX "F"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship
Report No. 4702
DR 12

by D. R. Christie

We have very little to report on this project at the present time, as the writer has been devoting considerable time to project DR 5 and we have not been able to acquire an assistant to help carry on some experimental work at the Ontario Research Foundation.

A few qualitative experiments on phosphate cements have shown that it is necessary to reduce the reactivity of ordinary zinc oxide and 85 per cent phosphoric acid. This can be accomplished by modifying the oxide (powder) or partially neutralizing the acid (liquid). The modification of the powder would require some form of calcination or fusing. The easier procedure of neutralizing the liquid would be the logical thing to do first.

Phosphoric acid was partially neutralized with zinc oxide and aluminum hydrate and with zinc oxide and magnesium sulphate. The clear liquids resulting were then reacted with various salts in the attempt to form cements. Aluminum hydrate and/or zinc oxide dental powders were the only ones tried which would give cements that would set in a relatively short time. That formed with aluminum hydrate appeared to be slightly less opaque than a cement made with commercial dental cement materials, but no quantitative measurements were made.

The ideal cement would, of course, be transparent. The field of synthetic resins would probably be the most promising in this regard. Since direct acrylic inlays can be made with some success, it seems logical that an acrylic cement which could be rapidly polymerized at 98°F. could be developed with the proper catalyst system.

February 6, 1947.

NATIONAL RESEARCH COUNCIL

Draft By-Law respecting National Research Council
Committees

1. Each Committee established by the National Research Council shall be assigned one of the following official titles:

- "The Associate Committee of the National Research Council
on, or
- "The Special Committee of the National Research Council
on, or
- "The Standing Committee of the National Research Council
on

The functions of an Associate Committee within an assigned field, may be entirely advisory, or they may be advisory combined with responsibility for the planning and direction of research work within the assigned field.

The functions of a Special Committee shall be similar to those of an Associate Committee, the main difference shall be in the degree of permanence of the proposed activity and/or its degree of importance.

A Standing Committee shall be an internal Committee of the National Research Council, with a membership which is composed exclusively or mainly of members of the National Research Council.

2. The terms of reference, the membership, and the appointment of a Chairman and of a Secretary of an Associate, Special or Standing Committee may be fixed, and revised from time to time as required, only by the National Research Council.

3. A concise statement of the purpose for which a Committee has been appointed shall be recorded when it is being established.

4. The members of a Committee shall be chosen, when practicable, primarily for their technical knowledge and experience and/or the contribution which they can make to the work of the Committee. The National Research Council shall determine in the case of each committee whether or not there should be rotation in membership, and whether retiring members should be eligible for re-appointment. If there is to be rotation in the membership, each member shall be appointed for a fixed period expiring 31 March, in a specified year.

5. The Chairman of a Committee shall be responsible to the National Research Council through the President, for the direction of all activities undertaken by the Committee, and for the submission, annually, of a report covering all such activities, or at such more frequent intervals as the President may request. The Chairman shall convene meetings of the committee when necessary, and shall preside at such meetings, and shall be responsible for insuring that an orderly and correct record is prepared of all questions discussed and decisions reached at meetings of the Committee.

6. The Secretary of a Committee shall be responsible for assisting the Chairman in any way practicable in the administration of the activities of the Committee. When requested by the Chairman he shall notify members of meetings of the committee, and shall make all necessary arrangements therefore. He shall attend all meetings of the Committee and make an accurate record of all questions discussed and decisions reached, and he shall receive a copy of all documents presented for consideration by the Committee. He shall submit his draft minutes to the Chairman of the Committee for approval or necessary revision. On approval of the minutes by the Chairman, the Secretary shall prepare and shall forward a copy of the complete proceedings of the meeting to the Chairman of the Committee, and to the President and the Secretary-Treasurer of the National Research Council, and to such other persons as the committee or the President, may direct from time to time.

It shall also be the responsibility of the Secretary of a Committee to notify all persons concerned, of all decisions reached or action taken by the Committee. (For this purpose, it is not sufficient merely to distribute a copy of the minutes).

The Secretary of a Committee shall follow the general policy of the Council with respect to the administration of committees, and shall observe any instructions which may be issued from time to time, by the National Research Council for the guidance of committees.

7. The research programme of a committee, when approved by the Committee and all additions and/or revisions thereto, shall be recorded as an Appendix to the official minutes of the meetings of the Committee at which such approval is given.

8. Grants in aid of research awarded by a Committee shall be subject to the Assisted Researches regulations and procedures of the National Research Council. The Secretary-Treasurer of the Council shall be promptly informed of each such award by the Committee Secretary, and furnished with the original copy of the covering application for the official records of the Council.

9. Reports covering research projects carried on under the auspices of a committee shall be secured at least annually by the Committee. Following consideration of such reports by the Committee, they shall be forwarded by the Secretary of the Committee to the Secretary-Treasurer of the Council for purposes of record and safekeeping.

Any report which contains secret or confidential information shall be clearly so marked, and shall be accompanied by an explanation as to the nature of the secrecy. Such reports shall be transmitted as secret documents.

10. A Committee may be empowered by the Council to appoint Subcommittees, and to fix the terms of reference, and to appoint the members, the Chairman and the Secretary of each Subcommittee, but these powers may not be delegated by the Committee to a subcommittee. Action appointing a subcommittee or revising its

terms of reference, or its membership or its officers, shall become effective only after the Secretary of the Committee has formally notified the Secretary-Treasurer of the National Research Council of the action taken by the Committee, and has furnished the Secretary-Treasurer with a copy of the terms of reference, a list of the members, and names of the Chairman and of the Secretary of the subcommittee concerned, or of any revisions thereof.

11. The Secretary-Treasurer of the Council shall be responsible for the overall guidance and correlation of the administrative activities of the committees of the Council, in accordance with the policies and procedures fixed by the Council from time to time. Consequently, the Secretary of each committee shall promptly inform the Secretary-Treasurer of all administrative action taken by the Committee of which he is secretary, and shall consult the Secretary-Treasurer regarding questions of policy and procedure.

12. The basic terms of reference, as set forth in Appendix "A" hereto, shall be assigned in so far as applicable and practicable to all Committees appointed by the National Research Council.

APPENDIX "A"

Basic Terms of Reference for Committees

In these terms of reference, the word
"field" shall mean the field of
"Committee" shall mean the Associate (or Special Committee
on
"Chairman" shall mean the Chairman of the Committee.
"Secretary" shall mean the Secretary of the Committee.
"Council" shall mean the National Research Council.
"President" shall mean the President of the National
Research Council.
"Secretary-Treasurer" shall mean the Secretary-Treasurer
of the National Research Council.

The Associate Committee on is hereby
assigned the following terms of reference.

1. To gather information required to enable the Committee to be fully informed as to the present state of knowledge in the field, and particularly the research work in progress in Canada, and to advise the Council on the collection and dissemination of research information generally in this field.
2. To prepare a list of specific projects in the field, on which research should be undertaken in Canada, and to revise and add to this research programme from time to time.
3. To investigate and review from time to time the facilities which exist in Canada for research in the assigned field.
4. To initiate, stimulate, and correlate research work in Canada in the assigned field.
5. To serve in a liaison capacity between the Council and Government, educational and other organizations or agencies, engaged in or concerned with research in the assigned field.
6. To prepare and submit to the Council prior to 1 October each year an estimate of the total financial requirements for the fiscal year beginning 1 April following.
7. Within the limits of the funds allotted to the Committee each year, to award grants in aid of specific research projects to persons competent to direct such projects, and who have normal laboratory facilities at their disposal.
8. To secure a progress or other report at least annually, from the director of each project, and to give careful consideration to each such report.

9. To make recommendations to the National Research Council from time to time, on any question within these terms of reference, when in the judgment of the Committee this is desirable or necessary.
10. The Committee may appoint subcommittees for the more effective prosecution of its work. The Committee shall fix specific terms of reference for each subcommittee which it appoints and shall appoint its members, its Chairman and its Secretary.
11. The Committee shall prepare, and submit to the President of the National Research Council on or before 31 May each year, a report covering the activities of the Committee during the official year ended on the 31st March preceding.

INITIAL DISTRIBUTION

Term to Expire

* 1. Dr. R. G. Ellis, Chairman	31 March, 1948
2. President C. J. Mackenzie (ex officio)	--
<u>Rep. Dental Profession</u>	
3. Dr. H. K. Box	31 March, 1949
* 4. Dr. E. Charron	31 March, 1948
5. Dr. D. S. Coons	31 March, 1949
6. Dr. M. H. Garvin	31 March, 1947
7. Dr. W. J. Linghorne	31 March, 1948
8. Dr. H. R. MacLean	31 March, 1947
9. Dr. G. D. Stibbs	31 March, 1949
<u>Rep. ^{ROYAL CANADIAN} Army Dental Corps</u>	
* 10. Col. ^{E.} M. M. Wansbrough (ex officio)	--
<u>Rep. Division of Dental Health</u> <u>Dept. Nat. Health and Welfare</u>	
11. Dr. L. V. Janes (ex officio)	--
<u>Rep. Basic and Med. Sciences</u>	
12. Dr. C. H. Best	31 March, 1947
13. Dr. E. F. Burton	31 March, 1949
14. Dr. J. B. Collip	31 March, 1949
15. Dr. O. W. Ellis	31 March, 1948
16. Dr. J.K.W. Ferguson	31 March, 1948
17. Dr. A. R. Gordon	31 March, 1947
18. Dr. D. Mainland	31 March, 1948
* 19. Dr. D. L. Thomson	31 March, 1947
20. Mr. S. J. Cook, <u>Secretary</u>	--
21. Office Copy (General Secretary)	--
22. Board Room Copy	--
23. Library	
24-33 Reserve	

* Members of the Executive.

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COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
THIRD MEETING
OF THE
EXECUTIVE
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

21 OCTOBER, 1947

Proceedings of the Third Meeting
of the

EXECUTIVE

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Chateau Laurier

8 a.m., 21 October, 1947

1. Attendance

Dr. R. G. Ellis, Chairman
Dr. E. Charron
Dr. D. L. Thomson
Col. W. M. Wansbrough

Mr. S. J. Cook, Secretary,

2. Consideration of Business Arising from the Proceedings
of the Fifth Meeting of the Associate Committee

(i) Dr. Bagnall's Bibliography (Min. 6(vii))

THE CHAIRMAN read a letter which he had sent to the Canadian Dental Research Foundation to inquire whether they would be willing to publish Dr. Bagnall's Bibliography. He explained that the Foundation has a substantial fund and can use the interest on this fund for the publication of research results in the field of dentistry. He had not yet received official assurance that the Foundation would be willing to publish Dr. Bagnall's book but he believed this matter would be given quite favourable consideration.

(ii) Grants under DR 5, DR 12 and DR 11 (Min. 6)

THE CHAIRMAN reported that he had met with officers of the Ontario Research Foundation and had discussed the question of funds for DR 5 and DR 12 for which a total of \$6100. had been asked. It was noted that project DR 5 is approaching completion while project DR 12 still requires considerable research. As a result of the discussion it had been agreed to ask the Committee for \$5,000. for the conduct of projects DR 5 and DR 12 in 1947-48 and an application had been submitted on this basis.

Regarding Dr. Godfrey's grant under DR 11 for which \$2850. had been encumbered at the Fifth Meeting, it had been found that the item of "miscellaneous equipment, \$300." in the application could be dropped as satisfactory apparatus had now been made available to the grantee from other sources. The grant had therefore been reduced to \$2550.

A letter ballot of the Executive regarding these three grants had been approved and was now being reported to the Executive for the record.

(iii) Establishment of Fellowships (Min. 14)

THE CHAIRMAN said that he had obtained from the Secretary copies of the National Research Council Regulations governing (a) the award of bursaries, studentships and fellowships in the field of the natural sciences and (b) the award of graduate medical research fellowships.

The general science scholarships are granted to graduate students who have won high distinction in scientific studies during their undergraduate courses, and are intended to assist such students to continue the pursuit of scientific research with a view of adding to fundamental knowledge or developing applications of science in Canadian industries. To be eligible for a first award an applicant must not have passed the 30th anniversary of his birth on 31 March of the year of application except in the case of war veterans. Bursaries are of the value of \$450.; studentships, \$750.; and fellowships, \$900.

Graduate medical research fellowships are designed to provide a mental discipline in research and to enable those showing an aptitude for research to obtain the training and experience in one of the basic medical sciences necessary to qualify them for medical teaching and research. Fellowships of the value of \$1,000. to \$1,200. per annum are open to graduates in medicine with high distinction in scientific study after completion of one year in post-graduate training. Fellowships of the value of \$1500. to \$2400. per annum are open to graduates in medicine who have had experience in research work and have shown distinct evidence of capacity for original research.

DR. THOMSON said that graduates in medicine and dentistry were in general older men than those who had graduated from a four-year course in science and that moreover they were fully qualified to practice their profession whereas the science graduate usually considered that his

training was not complete until he had obtained the Master's or Doctor's degree. Science scholarships granted by the National Research Council were intended to provide assistance to brilliant graduates who wished to continue their training to the doctorate level. In the case of medical doctors and dentists, time spent in research after graduation had to be considered in relation to the earning power that such participants might enjoy in the practice of their profession for which they were already qualified. It seemed reasonable therefore that medical research fellowships should carry a higher rate than the science scholarships.

There was some discussion as to whether it might be possible to secure a higher rate for dental fellowships and still retain them within the Council's general scholarships plan. The alternative was to recommend that funds be provided by the Council for the award of scholarships or fellowships directly by the Associate Committee on Dental Research. It was AGREED to canvass the matter further before reporting finally to the Committee. In the meantime it was AGREED to recommend the inclusion of \$5,000. for fellowships in the Committee's estimates for 1948-49.

The Meeting adjourned at 9 a.m.

INITIAL DISTRIBUTION

		<u>Term to Expire</u>
* 1.	Dr. R. G. Ellis, <u>Chairman</u>	31 March, 1948
2.	President C. J. Mackenzie (ex officio)	--
	<u>Rep. Dental Profession</u>	
3.	Dr. H. K. Box	31 March, 1949
* 4.	Dr. E. Charron	31 March, 1948
5.	Dr. D. S. Coons	31 March, 1949
6.	Dr. M. H. Garvin	31 March, 1950
7.	Dr. W. J. Linghorne	31 March, 1948
8.	Dr. H. R. MacLean	31 March, 1950
9.	Dr. G. D. Stibbs	31 March, 1949
	<u>Rep. Army Dental Corps</u>	
* 10.	Col. W. M. Wansbrough (ex officio)	--
	<u>Rep. Division of Dental Health</u> <u>Dept. Nat. Health and Welfare</u>	
11.	Dr. H. K. Brown (ex officio)	--
	<u>Rep. Basic and Med. Sciences</u>	
12.	Dr. C. H. Best	31 March, 1950
13.	Dr. E. F. Burton	31 March, 1949
14.	Dr. J. B. Collip	31 March, 1949
15.	Dr. O. W. Ellis	31 March, 1948
16.	Dr. J. K. W. Ferguson	31 March, 1948
17.	Dr. D. Mainland	31 March, 1948
18.	Dr. J. J. Rae	31 March, 1950
* 19.	Dr. D. L. Thomson	31 March, 1950
20.	Mr. S. J. Cook, <u>Secretary</u>	--
21.	Office Copy (General Secretary)	--
22.	Board Room Copy	--
23.	Library	
24-33	Reserve	

*Members of the Executive.

UNIVERSITY OF TORONTO
FACULTY OF DENTISTRY
OFFICE OF THE DEAN

RECD. DEC 11 1947

ANSWERED.....

REFERRED TO.....

FILE.....

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COPY NO. 1

NATIONAL RESEARCH COUNCIL OF CANADA

PROCEEDINGS
OF THE
SIXTH MEETING
OF THE
ASSOCIATE COMMITTEE
ON DENTAL RESEARCH

OTTAWA

21 OCTOBER, 1947

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- A - Research on denture base materials and denture preparation by A. E. R. Westman
- B - An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides by J. J. Rae
- C - A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines by R. J. S. Tickle
- D - Critical survey of the literature on dental caries by J. S. Bagnall
- E - Investigation of cements for methacrylate inlays by A. E. R. Westman
- F - The development of culture technique for certain fungus-like organisms found in periodontal disease by C. H. Best
- G - An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth by R. F. Shaner
- H - Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry by E. A. Sellers
- I - An anatomical, histological and physiological study of the role of the condyle in mastication by R. J. Godfrey
- J - A study of micro-organisms found in periodontal pockets and dental caries, as revealed by the electron microscope by H. K. Box
- K - Experimental production of dental caries by H. K. Box
- L - A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario by M. Doreen Smith
- M - Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries by M. Doreen Smith

Appendices (cont'd)

- N - To study the effects of altitude acceleration and deceleration on oral tissues by E.M. Wansbrough
- O - An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry by Drs. O. J. Walker and H. R. MacLean
- P - Tropicalization of dental supplies and equipment by Dwight S. Coons
- Q - A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth by H. K. Box
- R - By-law respecting National Research Council Committees and Basic Terms of Reference for Committees approved at the 161st meeting of Council held 12 September 1947.
- S - Summary of work on the development of a treatment of "Trench Mouth" by National Research Council, D. F. Stedman.

Initial Distribution

NATIONAL RESEARCH COUNCIL

Proceedings

of the

SIXTH MEETING

of the

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Held in the Council Chamber

National Research Building

9:30 a.m., 21 October 1947.

1. Attendance

Members

Dr. R. G. Ellis, Chairman

Dr. H. K. Box

Dr. H. K. Brown

Dr. E. Charron

Dr. D. S. Coons

Dr. J. K. W. Ferguson

Dr. M. H. Garvin

Dr. W. J. Linghorne

Dr. H. R. MacLean

Dr. D. Mainland

Dr. J. J. Rae

Dr. D. L. Thomson

Col. E. M. Wansbrough

Mr. S. J. Cook, Secretary

By Invitation

Mr. D. R. Christie

Dr. G. M. MacDonald

Dr. C. H. Moses

Apologies for their absence were received from

Dr. C. H. Best, Dr. J. B. Collip, Dr. O. W. Ellis and Dr. G. D. Stibbs.

2. Chairman's Remarks

THE CHAIRMAN welcomed Dr. Rae who had been appointed a member of the Committee in place of Dr. A. R. Gordon, resigned. He also

welcomed Dr. H. K. Brown who had now joined the Committee as the representative of the Division of Dental Health, Department of National Health and Welfare, in succession to Dr. L. V. Janes, resigned. He expressed the appreciation of the Committee in having Mr. Christie, Dr. MacDonald and Dr. Moses at the meeting to present reports on their respective projects.

He said that a meeting of the Executive had been convened at 8 a.m., 21 October, 1947, to review several matters which the Committee had referred to the Executive for consideration. He asked the Secretary to present a summary report of the Executive Meeting.

3. Third Meeting of the Executive

THE SECRETARY reported that the following items had been considered and action taken as indicated:

(i) Dr. Bagnall's Bibliography (Min. 6(vii) 5th Mtg.)

The Chairman had reported that he had written to the Canadian Dental Research Foundation to inquire whether that organization would be willing to consider the publication of Dr. Bagnall's book. While he had not received direct assurance in this matter he was under the impression that the Foundation would be likely to give favourable consideration to the proposal.

(ii) Grants under DR 5, DR 12 and DR 11 (Min. 6)

A meeting with the Ontario Research Foundation had been held regarding the allotment of funds under grants DR 5 and DR 12 and it had been agreed that the total sum provided by the Committee for these two grants for 1947-48 should be \$5,000.

Regarding DR 11, \$2850. had been encumbered but the Secretary had been asked to inquire regarding an item of "miscellaneous equipment, \$300." included in the application. He had found that later it had not been necessary for the grantee to buy the proposed equipment and the grant had therefore been reduced to \$2550.

Approval of the grants for DR 5 and 12 and 11 had been given by the Executive in a mail ballot.

(iii) Fellowships (Min. 14)

Consideration had been given to the general question of fellowships for dental research but the Executive wished to pursue the matter further before bringing in definite recommendations to the Committee. It had been agreed, however,

to recommend the inclusion of \$5000. in the Committee estimates for 1948-49 to provide for fellowships and not to ask for an increased allocation of funds for assisted research grants in the coming year.

It was MOVED by Col. Wansbrough and SECONDED by Dr. Thomson:

That the report on the meeting of the Executive presented by the Secretary be accepted. APPROVED.

4. Minutes of the Fifth Meeting

THE CHAIRMAN said that the proceedings of the Fifth Meeting of the Committee had been distributed to the members.

It was MOVED by Dr. Mainland and SECONDED by Dr. Linghorne:

That the proceedings of the Fifth Meeting of the Committee, having been circulated, be taken as read and approved. CARRIED.

5. Business Arising Out of the Minutes

(i) Tropicalization Report- (Min. 5(v))

DR. COONS presented a summary of the report on the tropicalization of dental supplies and equipment. He said that this summary had been approved for presentation to the Committee by the Department of National Defence.

DR. FERGUSON inquired whether the report on tropicalization would be published as he thought the information would be of interest to manufacturers of dental equipment who might be concerned in export trade with tropical countries and that it might also be useful to members of the profession in tropical areas.

DR. THOMSON thought that it would be specially valuable in the West Indies.

DR. COONS said he thought the report was chiefly of interest to the Armed Forces and he suggested that his summary be tabled and published in the proceedings of this meeting.

THE CHAIRMAN thought it would be useful if members would read this report in the light of the present discussion and be prepared at the next meeting to make recommendations in regard to its publication.

General meeting

*N B
read*

It was MOVED by Dr. Linghorne and SECONDED
by Dr. Charron:

That the Executive be asked to review the
summary report presented by Dr. Coons on tropicalization
and to report to the Committee in regard thereto at
the next meeting. CARRIED.

The report on tropicalization by Dr. Coons
appears in full in APPENDIX "P"

(ii) Paper by Dr. Lucas - (Min. 6(ii))

THE CHAIRMAN said that a paper prepared by Dr. R.J.S. Tickle
entitled "Critique of Methods Used in Determining the Water
Vapour Content of Nitrous Oxide" had been submitted by
Dr. Lucas and had been approved by the Committee for publication.
The paper had been forwarded to the Secretary for onward transmission
to the Canadian Journal of Research. A decision had not yet been
received as to the acceptability of the paper but an early report
was expected.

(iii) New Members of the Committee - (Min. 13)

THE SECRETARY reported that the National Research Council at its
meeting 12 September, 1947, had approved the recommendation
made by the Committee regarding the renewal of appointments
of the members whose terms expired 31 March, 1947, with the
exception that Dr. J. J. Rae had been named instead of
Dr. A. R. Gordon. This change had been made at Dr. Gordon's
request.

The following members have therefore been appoint-
ed for a term of three years from 1 April 1947 -

Dr. C. H. Best,
Dr. M. H. Garvin,
Dr. H. R. MacLean,
Dr. J. J. Rae,
Dr. D. L. Thomson.

6. Reprints of Papers

There was a short discussion on the purchase of
reprints of papers published by members of the Committee on work
arising out of researches supported financially or otherwise by
the Committee.

THE CHAIRMAN recalled that all papers arising out of assisted researches require approval by the Executive before publication (min. 6, 1st Mtg.; Min. 4, 2nd Mtg.; Min. 11, 3rd Mtg.) and that 25 reprints are required to be supplied to the Secretary for distribution to the members.

DR. GARVIN thought the Committee should arrange to obtain more than 25 copies in order that reprints might be available from the Secretary's office for distribution to persons other than members of the Committee who might ask for them.

DR. COONS suggested that the Committee might act as a repository of papers published by the members and that the stock should be kept in the Secretary's office.

DR. RAE said it was common practice to refer requests for reprints to the authors of papers and he thought that most people would follow this procedure.

It was MOVED by Dr. Coons and SECONDED by

Dr. Garvin:

That the Committee arrange to secure an adequate supply of reprints of papers by its grantees for distribution ; that is, a supply in addition to the 25 reprints required for distribution to the members, (i.e. one hundred copies in addition to the author's requirement). CARRIED.

7. Consideration of Reports

(i) DR 1 - Dr. James J. Rae

"An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides"

DR. RAE presented a summary of the work done to date and tabled an interim report for the period 1 Feb. - 30 June, 1947. The summary and the report appear in APPENDIX "B"

(ii) DR 2 - Dr. Geo. H. Lucas

"Chemical study of nitrous oxide for dental anaesthesia"

DR. FERGUSON presented a summary report by Dr. R.J.S. Tickle on work done under this grant. He pointed out that the failure of gas machines to deliver the amounts of gas indicated on the dial is a very serious matter. The onus is placed on the doctor or dentist administering the gas, to safeguard the patient's welfare, and it is essential that the person administering the gas should know exactly how much is being delivered at any given time.

DR. RAE thought the responsibility for checking the accuracy of the machines should rest with the Government rather than with the manufacturers of the equipment. He pointed out that the question was one of broad interest as hospitals and medical doctors were as much concerned as dentists in the accurate measurement of gas used for anaesthesia.

DR. CHARRON suggested that the work be continued until the grantees are satisfied with their results at which time it should be possible for the Committee to determine what further action could be taken to deal with the problem.

DR. FERGUSON said that if the manufacturing companies could be made even partially responsible for the accuracy of the equipment, it would be an incentive for them to exercise the greatest possible care in the manufacture and testing of gas delivery equipment. He outlined a further programme of work in which the cooperation of anaesthetists and engineers would be required and said that he thought it would be worthwhile to pursue the investigation further.

It was MOVED by Dr. Linghorne and SECONDED
by Dr. Charron:

That Dr. Ferguson be given authority to proceed with the investigation under DR 2 along the lines he had outlined to the Committee and in cooperation with anaesthetists in Toronto. CARRIED.

THE CHAIRMAN said that consideration might be given later to increasing the amount of the grant if Dr. Ferguson thought that more funds were needed for the study.

The summary report by Dr. Tickle under DR 2
appears in APPENDIX "C"

(iii) DR 3 - Dr. H. K. Box

"A study of micro-organisms found in periodontal pockets and dental caries, as revealed by the electron microscope"

DR. H. K. BOX presented an interim report on DR 3 which appears in APPENDIX "J"

He also circulated several electron microscope photographs of organisms found in periodontal pockets.

(iv) DR 4 - Dr. H. K. Box

"A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth"

DR. LINGHORNE presented this report which appears in full in
APPENDIX "Q"

He pointed out that the report was in two parts as it had been found desirable to embark on a slightly different line of research in order to interpret some of the findings gained in the main research.

There was considerable discussion at this point on the question of dividing the investigation into two projects and it was generally agreed that the work should be restricted to the field set out in the initial application and that if necessary a new project should be established with a separate number to carry on the other lines of research suggested by Dr. Linghorne.

DR. BOX expressed his willingness to continue the investigation on DR 4 in accordance with the original application.

DR. LINGHORNE reminded the Committee that the interim report on this project presented in Appendix "C" of the Fifth Meeting indicated the desirability of dividing the project into two parts.

After some further discussion it was MOVED by Dr. Garvin and SECONDED by Dr. MacLean:

That a small Committee, to be named by the Chairman, be appointed to confer with Dr. Linghorne in the planning of a new investigation along the lines he had suggested and to consider whether any modifications in the plans for the project under DR 4 should be made. CARRIED.

(v) DR 5 - Dr. A. E. R. Westman

"Research on denture base materials and denture preparation"

MR. D. R. CHRISTIE presented a summary and the complete report on DR 5. These two documents appear in
APPENDIX "A"

The following monthly progress reports on this project are also included in APPENDIX "A"

Report No. 4703	11 March, 1947
Report No. 4704	14 April, 1947
Report No. 4705	14 May, 1947
Report No. 4706	16 June, 1947

DR. CHARRON said that he had read the whole report very carefully and that he considered it both simple and effective. He thought the paper should be published and suggested that it should be submitted to the Committee for review in the usual way and then printed.

It was MOVED by Dr. Charron and SECONDED by Dr. Ferguson:

That the report on denture base materials and denture preparation by Dr. A.E.R. Westman be published. CARRIED.

THE CHAIRMAN suggested that this paper might be of interest to the Journal of the Canadian Dental Association or that perhaps the Canadian Dental Research Foundation might like to publish it as a Bulletin.

(vi) DR 6 - Dr. E. M. Wansbrough

"To study the effects of altitude acceleration and deceleration on oral tissues."

COL. WANSBROUGH presented a brief summary of the work under this project pointing out that the research is proceeding during spare time at RCAF Station, Eglington.

He said that Major E. C. Purdy had prepared a bibliography of 106 references on aviation dentistry and as he thought this bibliography would be of general interest to members of the Committee, he tabled a copy.

Both the summary report and the Bibliography of Aviation Dentistry appear in APPENDIX "N"

(vii) DR 7 - Dr. J. S. Bagnall

"Critical survey of the literature on dental caries"

THE CHAIRMAN presented a summary of the work under this project by Dr. Bagnall which appears in APPENDIX "D"

He reminded the members that the Executive had explored some of the possibilities of publishing Dr. Bagnall's Bibliography and said that he thought Dr. Bagnall was doing an excellent piece of work.

DR. MAINLAND said that he understood the critical part of Dr. Bagnall's Bibliography was not now likely to be extensive and that Dr. Bagnall had told him it was his intention to prepare a Bibliography with a good index as he thought this would be the most useful form in which he could present the data.

THE CHAIRMAN said that he expected the work on the Bibliography would probably be completed before the next meeting of the Committee is held.

(viii) DR 9 - Drs. O. J. Walker and H. R. MacLean

"An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry"

DR. H. R. MACLEAN presented a summary report which appears in APPENDIX "O"

(ix) DR 10 - Dr. G. M. MacDonald

"Facial prostheses constructed of vinyl resins"

DR. MACDONALD spoke briefly on the work he had undertaken under this project and showed some samples of facial prostheses made from various materials. He said that the vinyl resins used had been obtained from two sources, one in the southern states and the other at Shawinigan Falls. The powder is plasticized into a thick doughy material and then processed in dry heat at 150-160°C. Colouring matter consisting of pigments and oil paints is added and after processing the material is trimmed and tinted if necessary. Most facial prostheses are satisfactory for temporary requirements but the material deteriorates and becomes hard. It is affected by the ultraviolet light in outside air. He promised to submit a full report for the February meeting.

(x) DR 11 - Dr. R. J. Godfrey

"An anatomical, histological and physiological study of the role of the condyle in mastication"

DR. C. H. MOSES presented a short report on this project. It appears in APPENDIX "I"

DR. MOSES discussed the report at some length and showed skull models to illustrate his ideas on the movement of the condyle.

A letter from Dr. Godfrey reporting on a visit by Dr. Moses and himself to Dr. E. R. Granger, Mount Vernon, New York, for discussions regarding the use of recording devices and the gnathoscope is also included in APPENDIX "I"

Luncheon adjournment 1 to 1:45 p.m.

(xi) DR 12 - Dr. A. E. R. Westman

"Investigation of cements for methacrylate inlays"

MR. D. R. CHRISTIE presented a report on this project which appears in APPENDIX "E"

The following monthly progress reports on this project are also included in APPENDIX "E"

Report No. 4703, 11 March, 1947
Report No. 4704, 14 April, 1947
Report No. 4705, 14 May, 1947
Note 16 June, 1947

(xii) DR 13 - Dr. M. Doreen Smith

"A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario"

THE CHAIRMAN presented the summary of the work done under this project which appears in APPENDIX "L"

He said that it would be of interest to compare a microbiological method of determining fluorine content of teeth with known chemical methods to ascertain the usefulness of such procedures. He suggested that Dr. Smith might be invited to attend the next meeting of the Committee to present her report.

(xiii) DR 14 - Dr. M. Doreen Smith

"Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries"

THE CHAIRMAN presented a summary report by Dr. Smith which appears in APPENDIX "M"

DR. BROWN said that the Department of National Health and Welfare was proposing to undertake fluorine surveys in certain areas in Ontario. He mentioned that Brantford is now adding a trace

of fluorine to its drinking water supply and some other places such as Stratford, have been using a water supply for many years which contains a trace of fluorine. Sarnia on the other hand has a water supply that is free of fluorine. It is of interest from the point of view of dental research to examine the teeth of children in these different areas to determine what effect the presence or absence of fluorine in the drinking water has had on them.

DR. THOMSON said that Dr. Smith's project DR 14 appeared to involve two problems (i) What is the fluorine content of the food intake of the populace? (ii) What is the relationship of the fluorine content of water and soil to the fluorine content of foodstuffs grown in a given area? He pointed out that much of the food eaten in a fluorine-free area might be derived from other sections in which fluorine is present in the soil and water, and vice versa.

(xiv) DR 15 - Dr. Norma Ford Walker

"A comparison of the patterns of eruption of the deciduous teeth in man with rates of growth of the dental arches"

No report was received on this project.

(xv) DR 16 - Dr. C. H. Best

"The development of culture technique for certain fungus-like organisms found in periodontal disease"

DR. LINGHORNE summarized the work under this project from a report prepared by Dr. Best which appears in APPENDIX "F"

(xvi) DR 17 - Mr. R. F. Shaner

"An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth"

DR. MACLEAN presented the report by Mr. Shaner which appears in APPENDIX "G"

He said that Mr. Shaner was a graduate in mathematics and would this year graduate in dentistry. He thought that good progress was being made on the project.

(xvii) DR 18 - Dr. H. K. Box

"Experimental production of dental caries"

DR. H. K. BOX presented a summary of the work to date on this project but said that no definite conclusions could yet be drawn from the experimental work done. This summary appears in APPENDIX "K"

(xviii) DR 19 - Dr. E. A. Sellers

"Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry" APPENDIX"H"

DR. FERGUSON presented a report by Dr. Sellers on the investigation being carried out by Dr. H. S. Hamilton and complimented Dr. Hamilton on the progress made. He said that the subject was of more fundamental than practical interest.

DR. CHARRON said he was in some doubt as to the exact scope of the project and he thought the problem should be clarified.

THE CHAIRMAN said that he would invite Dr. Sellers or Dr. Hamilton to come to the February meeting of the Committee to discuss this project.

8. Application for Grants

- (i) Dr. Jules Thebaud Improvement of sub-gingival curettage and surgical techniques used in the treatment of pyorrhea alveolaris.

THE CHAIRMAN said that Dr. Thebaud proposed to spend about \$200. in the employment of part-time dental help at \$20. per month; casting and tooling of special instruments for investigation in pyorrhea treatment would cost \$300.; X-ray materials, \$150.; and chemicals and glassware, \$150. He said that Dr. Thebaud felt that present methods used in gum resection are somewhat too radical and he proposes to attempt to develop a more conservative procedure based on the accurate measurement of the depths of the periodontal pockets involving pathological tissue. The application had been submitted to Dean Charron who had asked that it be presented to the Committee.

It was MOVED by Dr. Box and SECONDED by Dr. Ferguson:

That the application be designated as DR 20
and APPROVED \$800.

- (ii) DR 2 Dr. G. H. W. Lucas (See Min. 7(ii))

After a short discussion on the question of increasing the amount of the grant under this project, it was MOVED by Dr. Box and SECONDED by Dr. Linghorne:

That the Executive be authorized to increase the appropriation under DR 2 upon receipt of a new application outlining the further work that is proposed to be done under this project. CARRIED.

(iii) DR 4- Dr. H. K. Box (See Min. 7(iv))

There was some further discussion on the question of dividing project DR 4 and setting up a new project to deal with the proposed work that does not come under the definition of DR 4 in the original application.

It was MOVED by Dr. Ceens and SECONDED by Dr. Mainland:

Exec That the Executive be asked to arrange a Conference on the investigations proposed under DR 4 and authorized to make a grant under a new project if this procedure is recommended by the Conference and an application is submitted. CARRIED.

9. Draft By-law Respecting Committees

THE SECRETARY said that a Draft By-law respecting National Research Council Committees (Min. 15, 5th Mtg.) had been submitted for study and published in Appendix "Q" of the Fifth Meeting of the Associate Committee on Dental Research.

However, the Draft By-law as previously submitted had since been modified slightly by the National Research Council and a copy of the By-law in its modified and final form was being included in these proceedings

APPENDIX "R"

THE CHAIRMAN said that the National Research Council wished all Associate Committees to have comparable terms of reference and that the Associate Committee on Dental Research should be prepared at its next meeting to complete its terms of reference according to the form approved by Council.

10. Budget, 1948-49

THE CHAIRMAN said that as recorded in the proceedings of the Third Meeting of the Executive it was proposed to recommend to the National Research Council that the budget for the Associate Committee on Dental Research for 1948-49 be increased by \$5,000. to permit the establishment of fellowships or scholarships for dental research now under consideration. He said that it was not proposed to ask for any additional funds for grants-in-aid of research projects as with careful screening of all applications it was thought that adequate provision could be made for such investigations as were approved by the Committee, in the sum of \$27,500. For travel \$2,500. should be provided and for contingencies the Secretary should have \$500. available.

It was MOVED by Dr. Mainland and SECONDED by
Dr. MacLean:

That the National Research Council be asked to allocate funds in the total sum of \$35,500. to the Associate Committee on Dental Research for the following purposes in 1948-49:

Grants-in-aid	\$27,500.
Fellowships	5,000.
Travel	2,500.
Contingencies	500.
TOTAL	\$35,500.

11. Correspondence

(i) Letter 16 October 1947 from Dr. J. J. Rae

THE SECRETARY reported that he had received a letter from Dr. Rae pointing out that Miss M. Davies a fourth year student had been assisting him in project DR 1 until the close of the academic year, 1 June 1947. He is in need of a replacement for her and can secure the services of Mr. John T. Dentay an ex-service student in the second year of the Honours Physiology and Biochemistry Course who is available on a half-time basis as he has been granted exemption from laboratory classes. Dr. Rae recommended that he be given \$250. additional under grant DR 1 to pay this technician's salary, November-March inclusive, at \$50. per month.

It was MOVED by Dr. Coons and SECONDED by
Dr. Mainland:

That the grant to Dr. J. J. Rae under DR 1 be increased by \$250. to provide for the payment of a technician for the remaining five months of the present fiscal year at \$50. per month, and that Dr. Rae be authorized to employ Mr. John T. Dentay in this capacity. CARRIED.

(ii) Letter 6 October 1947 from Dr. A. E. R. Westman re
DR 5 and 12

THE SECRETARY reported that Dr. Ellis had received the following proposal from Dr. Westman:

"(1) Growing out of DR-5 which is now completed is the realization that some work of considerable practical importance could be done on denture repair techniques. This is considered

of relatively more importance currently than the work of DR 12. Permission is requested to divide our attention and grant between DR 12 and a new project DR- -. "Investigation of Repair Techniques for Methacrylate Dentures".

"(2) We should like the Committee to consider the advisability of publishing the DR 5 report after suitable editorial revision. It is suggested that publication in the Canadian Journal of Research with a distribution of reprints to the dental profession through some suitable organization would serve the needs of the situation".

After some discussion it was MOVED by Col. Wansbrough and SECONDED by Dr. Box:

That Dr. Westman be invited to submit a new application covering his proposed project on "Investigation of Repair Techniques for Methacrylate Dentures" CARRIED.

(Action has already been taken on paragraph two of Dr. Westman's letter; see Min. 7(v))

(iii) Letter dated 14 October, 1947, from Dr. D. F. Stedman

THE SECRETARY read the following letter which he had received from Dr. Stedman of the Division of Chemistry, National Research Council:

" During wartime we were requested by the Canadian Dental Corps to assist in the development of a treatment for trench mouth which would require less personal time of the dentist. In the early war years their staff became gradually more and more occupied in combatting the acute phase of Vincent's infection and it had reached the point where all cases had to be dropped as soon as this acute attack had been arrested, leaving almost no time for the really more important corrective work.

" In cooperation with the C.D.C. we succeeded in finding a simple mouth wash which would arrest the acute phase of this condition without the need for any dentist's time at this stage.

" I thought perhaps your Committee might be interested in this work and I consequently enclose copies of our reports".

THE SECRETARY was directed to ask Dr. Stedman whether a summary of these reports could be made for the information of the Committee; if this proved difficult he was authorized to include the complete reports in these proceedings. (See APPENDIX "S")

Meeting adjourned at 3:50 p.m.

APPENDIX "A"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: Research on denture base materials and denture preparation

Grantee: A. E. R. Westman

Project No. DR 5 Amount of Grant: \$5,000
(including DR-12)

SUMMARY OF WORK

A final summary report (4707-DR-5) on this project has been submitted by the Ontario Research Foundation.

Previous reports have outlined the development of a thermoduct method of processing dentures and the application of this method to the preparation of practical dentures. This work has now been completed and an evaluation of the thermoduct technique has been made.

By the thermoduct method, it is possible to cure a denture rapidly (in one hour or less) without causing thermal inequalities in the denture base material during polymerization.

The practicability of this method has been demonstrated in the preparation of several dentures for service.

In addition, another time-saving factor is the relative ease of deflasking. The presence of a thermoduct facilitates the removal of the cast from the processed denture.

In our investigation we found that, with the aid of channels cut in the lands of the plaster investment and extending through the walls of the dental flask, it is possible to reduce trial-packing to a minimum of two flask closures, although some experience is necessary in judging the required amount of denture base material. The elimination of several trial closures produced no deleterious effects on the processed denture.

" A-ii "

We have pointed out that the problem of polymerization shrinkage (the contraction which occurs as the result of a change in density as the monomer turns to the polymer) is not serious because this shrinkage is compensated by expansion due to water absorption. Any dimensional discrepancy is so small as to be of no practical significance.

During the course of this work our attention was drawn to distortion difficulties which are quite frequently encountered in making repairs. Our observations on the thermal behaviour of the denture material led us to ascribe this to the re-heating of the denture to the same range of temperatures as originally used. A few experiments, based on low-temperature cures for the repairs, supported this theory and have aroused considerable interest in the Foundation committee. This subject seems sufficiently important to warrant its being set up as a separate research project, in order that the practical details may be firmly established.

In addition to the laboratory work, the chemical and dental literature is constantly being reviewed for new developments in the fields of plastics and denture base materials as well as in subjects which could have a direct application to this project.

October 3, 1947.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4703 - 11 March, 1947

Subject: Research on denture base materials and denture preparation.

Author: D. R. Christie, Research Fellow

Project No.: DR 5

Scope

This report deals with additional work done at the Dental College of the University of Toronto on the application of the "anti-porosity" technique to the processing of practical dentures.

Experimental Work

(a) Thermoducts - It was learned that some changes would be required in the design of the thermoducts used in processing the dentures.

Thermoducts for lower dentures had not been made high enough to ensure that, when properly positioned in the denture cast and invested in the dental flask, the land of the investment was approximately horizontal and level with the rim of the bottom half of the flask. This defect was overcome by designing several brass plates which can be attached to the bottom of the thermoducts. When used in combinations they permit the adjustment of the thermoduct to various desired heights. Furthermore, some of the plates have been made with their top and bottom surfaces at slight angles to each other so that the denture can be invested at an angle which will facilitate deflasking. These details will be more apparent by referring to the accompanying diagram.

One or two modifications of the thermoducts for upper dentures were also required in regard to mounting the cast on an articulator. In this operation the cast for the upper denture is secured to the upper articulator bow by a layer of plaster

applied to the base of the cast. To ensure that the cast would not be jarred loose from its mounting and would be gripped tightly by the plaster, an undercut or trough was ground near the base of the thermoduct on all sides. In addition, for purposes of remounting to check the articulation of the teeth after the denture has been processed, two holes were countersunk in the base. These holes will enable the dentist or technician to place the denture in the same position on the articulator as it occupied during the waxing-up process before curing. These features are also shown in the diagram.

Processing of Practical Dentures

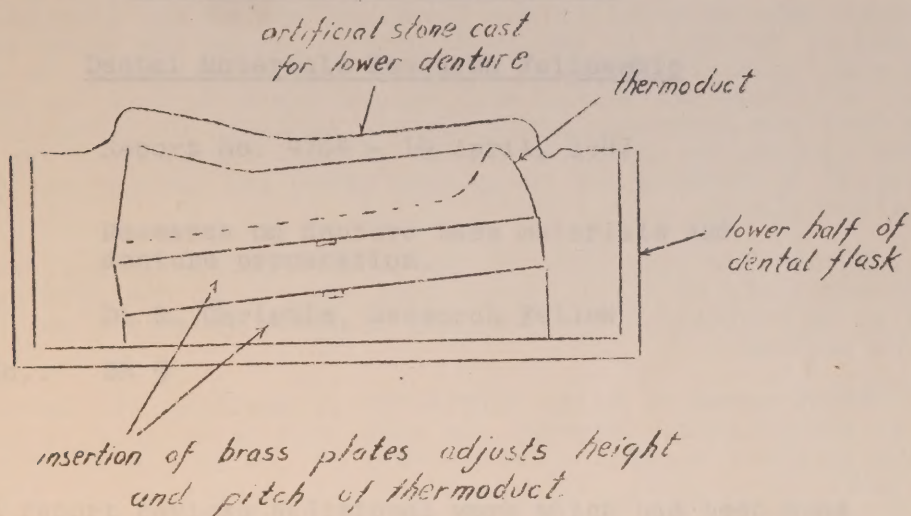
To date only one practical denture, a full upper, has been made. After the impression was taken the cast was poured and a thermoduct inserted in it. A student in charge of the case completed the waxing-up process, then it was returned to us for processing. No difficulties in articulator mounting were encountered and a satisfactory denture was turned out. A different technique was used to check articulation so that remounting was not necessary.

More cases will be processed in the near future, in fact, two are under way at this writing. A record is being kept and an evaluation of this technique and the one currently used at the Dental College will be made.

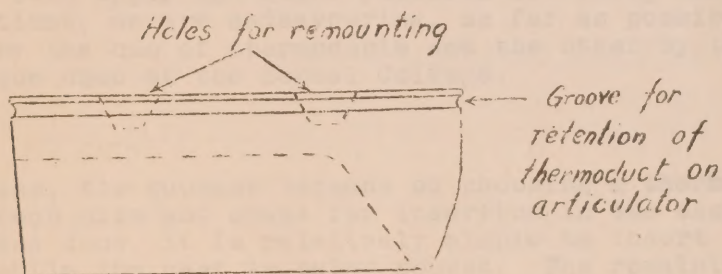
It is believed that this rapid cure not only eliminates porosity but effectively minimizes internal strains in a denture. This can be demonstrated by a laboratory study of the dimensional changes occurring in a denture during (a) curing, (b) water absorption and (c) recuring or repairing. The effects of (a) and (b) have received considerable attention but it remains to be seen what the effect of repair conditions will be.

The processing of practical cases will receive our immediate attention and, if time permits, an investigation of dimensional changes will be made.

CROSS - SECTION OF DENTAL FLASK SHOWING INVESTED CAST



SIDE VIEW OF THERMODUCT FOR UPPER DENTURE



APPENDIX "A"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4704 - 14 April, 1947

Subject: Research on denture base materials and
denture preparation.

Author: D. R. Christie, Research Fellow

Project No.: DR 5

Scope

This report reviews additional work which has been done at the Dental College of the University of Toronto on the processing of practical dentures.

Practical Cases

At the last writing one full upper denture had been processed satisfactorily by the thermoduct technique. Since then seven other cases have been started. Some have been completed while others are in various stages of construction. In those instances where both upper and lower dentures are being made for the same patient, we are endeavouring, as far as possible, to process one by the use of thermoducts and the other by the standard technique used at the Dental College.

Results

In every case, the success depends on choosing a thermoduct of the correct size and shape for insertion in the cast. When this has been done, it is relatively simple to insert the thermoduct while the cast is being poured. The remaining steps in the procedure for making a denture are then quite straight-forward. The thermoducts which we have used have dimensions which are averages of those taken from a number of specimen casts. So far these thermoducts have proved adequate for the dentures we have processed.

Report No. 4704 (cont'd)

In two cases, one a full upper and another a full lower, we encountered considerable porosity. This has been attributed directly to insufficient pressure caused by a deficiency of denture base material in the flask and not to the thermoduct method of curing. It was necessary to rebase the upper denture and when careful attention was given to trial-packing to ensure that the flask was packed with enough resin to fill the mold, the case was processed again with no evidence of porosity. The lower denture had porosity on the lingual flanges and can be repaired by cutting out the porous areas and packing new material in these places.

In another case made by the Dental College method, four anterior teeth of a full lower were checked at the pins and had to be replaced. The checking of these teeth was not caused by deflasking.

There seems to be no difficulty in mounting the casts on an articulator. However, as mentioned previously, a point which requires careful consideration is the selection of a suitable thermoduct. This is especially important for lower dentures for unless the thermoduct fits well and can be inserted in the cast so that it comes close to its bearing surface, an unusually high cast results. This cast may be too large to mount accurately on the articulator and a deep dental flask will be required for investing and processing.

One such case has occurred. Fortunately, the design of the lower thermoducts, which was illustrated in an earlier report, enabled us to remove the spacing plate and the cast could then be mounted without difficulty. This plate can be replaced when the denture is to be processed.

Evaluation of the Thermoduct Method

When more dentures have been completed, we will be better able to pass judgment on the thermoduct technique.

It is apparent that it offers a saving in processing time, requiring approximately half the time of the standard Dental College curing procedure.

We would also like to make some laboratory cases to study the effect of severe repair conditions on dimensional changes with the object of learning more about internal strains produced in dentures by these two methods of processing.

"S-A"

Report No. 4705 (cont'd)
DR 5

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4705 - 14 May, 1947

Subject: Research on denture base materials and
denture preparation

Author: D. R. Christie, Research Fellow

Project No.: DR 5

Scope

This report describes further work done at the Dental College of the University of Toronto on the processing of practical dentures.

Experimental Work

Since the last report several cases have been completed. At this stage we have made ten dentures, including 4 full dentures and 2 full lowers by the thermoduct technique and 1 upper and 3 lowers by the method used at the Dental College. We have also under way 3 other dentures, including 2 partials which should be completed very soon.

Since the college will be closing in about a month and in view of the fact that a considerable length of time is required to make a denture, we are not taking on any new cases. Although it would be desirable to process several more, we believe that an evaluation of the thermoduct method can be made when the present work is completed.

We have had photographs made of several dentures to show the type of cases which have been processed. The local Committee feels that photographs should be taken to show the texture of the denture base material as well. This will necessitate the recall of some patients and may not be possible in every case but we shall attempt to have it done.

Report No. 4705 (cont'd)
DR 5

In addition to the work on practical dentures, we have made a preliminary study on dimensional changes caused by recuring dentures. In the last report we described the changes which took place when 4 dentures (2 made by the thermoduct method and 2 by the Dental College method), were recured at 160°F. The change in all cases was about 1 per cent. These four dentures have been subjected to more severe recuring conditions at 212°F. for one-half hour, with the purpose of noting any appreciable difference in the dentures made by the two methods. All dentures suffered considerable warpage, about 1.4% on an average and no difference was observed. In view of these results, the local committee feels that additional work on dimensional changes would only result in a duplication of these results.

Conclusions

When we have completed the cases already under way, we should be able to make an evaluation of the thermoduct technique and then write a final summary report on this project.

"S-A"

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4706 - 16 June, 1947

Subject: Research on denture base materials and denture preparation.

Author: D. R. Christie, Research Fellow

Project No.: DR 5

The work on the processing of practical dentures at the Dental College of the University of Toronto has been completed and the next report on this project will be a final evaluation of the thermoduct technique.

Altogether nine cases have been made by the thermoduct method including five full uppers, two full lowers, a partial upper and partial lower. In addition to these, several cases have been made by the method commonly used at the Dental College in order to compare the two techniques. Photographs have been made of as many dentures as it has been possible to photograph and these will be included in the final report.

The important problem of repairs and warpage caused by the necessary repair conditions has been investigated further with promising results. Two full upper dentures were "repaired" by removing the two central incisors and replacing them by adding new denture base material. In one case one per cent of benzoyl peroxide catalyst was added to the monomer of the new denture base material. Since the dentures were repaired at the relatively low temperature of 120°F. it was expected that, if the methyl methacrylate without the added catalyst was insufficiently cured, then with the catalyst it would be carried to a higher degree of polymerization. However, after 65 hours at 120°F., both dentures seemed, on visual inspection to be satisfactorily repaired. Furthermore, both dentures showed excellent adaptation to their respective casts and occlusal indices which were made before recuring.

Report No. 4706 (cont'd)
DR 5

It is quite possible that a shorter time at 120°F. would suffice to produce satisfactory repairs. The local committee has agreed, then that it would be well worth while to prepare a series of test specimens, wherein the curing time and the quantity of added catalyst are variables, in order to determine exactly what conditions are required to produce a material which will meet the strength specifications for denture base materials.

Since this problem has a direct bearing on Project DR 5 and at the same time it is our desire to write off this project, the local committee has agreed that future research connected with or related to DR5 should be reported as supplements to this work.

APPENDIX "A"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4707 - DR-5

by

D. R. Christie

Introduction

During the last two years a research programme has been conducted here on problems associated with methyl methacrylate denture base material when used in a compression molding technique.

At the request of the Canadian Dental Corps, members of our staff visited the Training Centre in Toronto to learn about the problems at first hand and a series of investigations was proposed.

A description of the Canadian Dental Corps technique for making a denture will make clear the steps involved and the problems associated with them.

Description of Canadian Dental Corps Technique

A wax model, complete with teeth and finished to represent the completed denture, is made on an artificial stone cast of the mouth. The model and cast are invested in plaster in the lower half of a dental flask. The wax model, except for the teeth, is then covered with tinfoil. The top half of the flask is put in place and the tooth half of the investment plaster is poured. When the plaster has set, the flask is immersed in hot water to melt the wax, the halves of the flask are separated and the residual wax is flushed out with hot water. A separating medium of dilute sodium silicate followed by a concentrated solution is brushed on the hot cast and allowed to dry as the flask cools.

In the meantime, a mixture of monomeric methyl methacrylate (liquid) and methyl methacrylate polymer (which comes in the form of very small pellets or spheres and is commonly referred to as a powder) is made in approximately a 1:3 ratio. When this mix reaches a doughy consistency, it is ready for packing.

In packing the case, enough mixture to fill the mold cavity is put in, covered with wet cellophane and pressure is applied slowly by means of a bench press. The flask is then re-opened, more mixture added and pressure applied again. This trial-packing is continued until a smooth denture is obtained and the mixture has flowed into all crevices and depressions of the mold. It may have to be done five or six times.

After the final trial-pack, the cellophane is removed and the flask closed under pressure of a spring-compress. It is immersed in a water-bath which is brought to a boil over a period of one hour and kept boiling for a further three-quarters of an hour to polymerize the denture base material. The flask is then bench-cooled for 20 minutes and finally cooled in cold running water.

After deflasking, the denture is trimmed and polished mechanically.

Programme of Research

The following problems connected with the making of dentures were considered to warrant investigation. Each of these topics will be discussed more fully later in this report.

(a) Elimination of Trial-packing

A considerable saving in time would be effected if the flask could be filled in one operation instead of the five or six which were usually required.

(b) Elimination of Shrinkage

When the processed dentures were removed from the mold, it was frequently found that they had contracted laterally or were "pinched in" and would not accurately fit the cast against which they had been made.

(c) Development of a Faster Curing Method

Attempts to speed up the curing cycle described above, as by immersion of the flask in boiling water, resulted in a denture which was quite porous and completely unsatisfactory for use.

(d) Polishing by Chemical Methods

It was thought that chemical polishing would be a simple, time-saving operation to put a high gloss on finished dentures.

(e) Other Available Plastics

The possibility of using materials other than methyl methacrylate for dentures was to be considered by keeping up to date on developments in this field as outlined in the literature.

(f) Other Processing Methods

Information was also to be obtained about injection or other types of molding methods other than compression molding.

Some Physical Properties of Methyl Methacrylate

Monomeric methyl methacrylate is a colorless liquid whose chemical formula is: $\text{CH}_2 = \text{C}(\text{COOCH}_3) - \text{CH}_3$. At 20°C . its



specific gravity is 0.945 and its boiling point at 760 mm. pressure is 100.5°C . Methyl methacrylate polymer is a clear, colorless solid whose specific gravity is 1.19. The softening point of the polymer used for denture bases is approximately 185°F . Its water solubility is relatively small being about 0.1 per cent. It absorbs water to the extent of 1 to 2 per cent of its weight. In terms of dimensional changes, it is reported in the literature that this water sorption may cause a linear expansion across the ridges of a denture amounting to 0.3 to 0.5 per cent. The linear expansion due to water absorption approximately compensates for the shrinkage which occurs on polymerization.

It will be seen from the figures above that there is a volumetric change on polymerization of about 21 per cent. However, since the monomer represents only about one-quarter of the mixture used to make a denture this shrinkage will be reduced to 5 or 6 per cent. Theoretically, the linear polymerization should be the cube root of the volumetric shrinkage, but, because of the restraining influences of a complex mold shape, shrinkage is not the same in all directions. Values in

the literature for linear shrinkage are approximately 0.35 to 0.5 per cent. The net change in linear dimension (the difference between polymerization shrinkage and expansion due to water absorption) is very small and of little practical importance.

Methyl methacrylate has been chosen as a suitable denture base material because it has good color stability, it is strong, hard, and light in weight, because it can be suitably pigmented to give an excellent life-like appearance, because it remains relatively clean in the mouth and also because it can be easily molded at low pressures and cured at reasonably low temperatures. It is not a completely satisfactory denture base material as this report will make clear in subsequent sections, but if used in a suitable manner, highly efficient results can be expected.

Mixing of Monomer and Polymer

As previously stated, the monomer (liquid) and polymer (powder) are mixed in the ratio of about 1:3 by volume. Manufacturers' directions are usually included in all materials specifying the quantities to be used. We have found that these quantities can be varied within small limits and it is best to use the minimum amount of liquid for two reasons. Because methyl methacrylate has a large volumetric shrinkage on polymerization, the smaller the quantity of monomer in the mixture, the smaller the shrinkage will be. Also, a great excess of monomer will cause a type of porosity which is characterized by large localized pits or bubbles in the finished denture base.

It is good practice to add the powder to the liquid. In this way, the globules of polymer are more likely to be evenly wetted by the monomer. Some stirring is necessary to ensure that the liquid and the pigment on the powder particles are evenly distributed through the mixture. The monomer is a solvent for the powder and the mix passes through an initial stage when it resembles wet sand, to a sticky stage and then to a doughy consistency when it is ready for trial-packing.

The time required for these changes to take place varies with temperature but is usually 20 to 30 minutes. If

the powder and liquid are placed in a cold jar and put in a refrigerator, the mix requires many hours to reach a workable stage and may be used several days after that.

In our work we used the commercially available powder and liquid forms of Lucitone, for no other reasons than that it is readily available and is a satisfactory acrylic denture base material.

Trial-Packing

In our experience it is not feasible to eliminate trial-packing by calculating the quantity of resin to use on the basis of the ratio of the weights of the resin and the wax model. The model is usually a combination of wax and base plate material in varying amounts and frequently contains voids which would upset any calculations.

With some experience the number of flask closures can be reduced to a minimum. If the first trial-pack is made with enough of the resin mixture, the mold will be filled and a flash will be produced. In addition, the resin will be compressed enough so that no defects will result on processing. The flash can be trimmed off, a slight excess added and the dental flask closed in a spring-compress ready for curing. If small channels are cut in the land of the investment and extended through corresponding channels in the walls of the flask, the excess of resin can flow into them without danger of forcing the halves of the flask apart, thus "opening the bite" and this excess will also compensate to some extent for the shrinkage on curing.

Description of the Polymerization Process

Methyl methacrylate polymerizes readily under the influence of heat, light and catalysts such as benzoyl peroxide. The reaction is exothermic and eventually becomes auto-catalytic in that as the heat of polymerization is developed, the reaction proceeds more rapidly. Eventually, the polymerization goes so rapidly that a considerable evolution of heat results. Since the plaster investment and the denture base material itself are very poor heat conductors, it is very easy for a very high temperature to be developed in the resin.

For example, when a powder-liquid mixture of methyl methacrylate denture base material is cured rapidly, the follow-

ing usually occurs. The temperature of the resin increases gradually from its initial temperature to approximately 185°F. where suddenly the temperature increases very rapidly and may rise as high as 280°F. Just as quickly it falls again but in this short space of perhaps a minute or two considerable damage may result to the denture. Figure 1 is a graph of a typical rapid polymerization, the temperatures of which were measured by thermocouples inserted in the resin.

To control this reaction, some means must be provided for the heat of polymerization to be conducted away as fast as it develops. In the usual methods of denture making, the resin temperature can only be prevented from rising too high by keeping the ambient temperature as low as possible until polymerization is nearly complete. After a considerable degree of polymerization has occurred, it is safe to raise the ambient temperature without damaging the restoration.

Most curing techniques are adapted to this end. They make use of relatively low water-bath temperatures for considerable lengths of time followed by higher temperatures. An example of this technique is the cure used by the Canadian Dental Corps.

Porosity

One of the most commonly occurring defects in processed acrylic dentures is porosity. It has received the attention of numerous investigators since the acrylics first came into general use and at least five causes have been presented for its occurrence.

(1) Pin-Point Porosity

In the manufacture of the polymer powder, small voids are produced in each grain. They can be readily seen under a microscope. Occasionally, and especially in clear methyl methacrylate, these pin-point pits are visible in the finished product. This type of porosity is the least important and is found rather infrequently.

(2) Excess of Monomer

If the mixture contains too much monomer, the processed denture may contain very large localized pits or holes.

(3) Absorption of Monomer by Plaster

If the monomer-polymer mixture is placed in the mold next to the plaster or artificial stone, monomer may be absorbed leaving pits in the denture. This can be prevented by careful application of the separating media, such as tinfoil, sodium silicate or alginate type separator, to the surface of the investment.

(4) Insufficient Pressure

It is reported by Kelly* and Sweeney** that the bubbles occurring in this type of porosity are partial vacuums. This type of porosity can be avoided by ensuring that sufficient material is present in the mold so that a positive pressure can be applied during the cure. Figure 2 shows a photograph of a denture which was deliberately made with insufficient material in the mold to illustrate this kind of porosity.

(5) Volatilization of the Monomer

This is the most common cause of porosity. If the temperature of the resin greatly exceeds the boiling point of the monomer (100.5°C.) while it is still soft enough to flow, bubbles will form. This almost always happens if the cure is too rapid. It is the result of the exothermic reaction and the poor thermal conductivity of the plastic itself and the plaster and stone investment. When porosity occurs, it is more apt to do so in areas where the greatest bulk of resin exists or in the positions where the resin is nearest to the centre of the investment.

Figure 3 illustrates this type of porosity. This edentulous case was processed by immersing the dental flask in a boiling water-bath. Even though provision was made to conduct away the heat of polymerization by means of thermopods (this will be explained more fully in a later section), porosity resulted.

Internal Strains

It is virtually impossible to mold a denture without some internal strains in it, because the investment materials

* Dental Survey, Volume 21, January. 1945.

** J.A.D.A. 29, 7-33. 1942

(plaster and stone), the teeth (porcelain) and the denture base material all have different coefficients of thermal expansion. Strains resulting from these properties, cannot be removed by an annealing process.

However, all strains are not important from the point of view of subsequent distortion during use. Only those which relieve themselves and cause the denture to warp are significant.

If temperature differences occur during polymerization, local strains may quite easily be formed because of differences in degree of polymerization in various parts of the resin. Similarly, temperature differentials should be avoided in cooling a processed denture, therefore slow cooling is advisable.

It has been our endeavor with the curing method which we have developed here, and which will be outlined later, to minimize strains by controlling the heat of polymerization and eliminating local temperature effects and also to control cooling in the same way.

Observation of Strains

There are four methods of observing strains in a denture.

1. Heating in water.

As the denture base material is heated in water and approaches its softening point, strains are relieved and warpage or distortion occurs. In our investigations we have found that dentures will withstand temperatures up to 185°F., for 5 minutes at least, without showing any appreciable distortion. Above this temperature distortion becomes increasingly pronounced until at 212°F. it is quite severe. This does not mean that the dentures are unusable, only that in use they should never be immersed in very hot water.

2. Observation in polarized light.

The use of polarized light is confined to clear dentures where the strain patterns can be seen. Strains around porcelain teeth in a transparent denture are easily seen by this method. When plastic teeth are used, strains are very

greatly reduced. This would appear to be an argument for the use of plastic teeth.

3. Dimensional changes in service.

There are several references in the dental literature* to the fact that dentures with internal strains may change in dimensions over a considerable period of time. We have no evidence from our own laboratory experience that such changes do occur and, on the whole, the problem is not serious because, in practice, distortion occurs rather infrequently. Although little is definitely known about this subject, it is evident that internal strains may be one of several contributing factors.

In view of the possibility that these strains may cause distortion, it is well to guard against them where possible. One way, as Tylman states, is to avoid "extreme practices in the processing technique". This is exactly what we have endeavored to accomplish by using the thermoduct method to eliminate extreme local concentrations of heat in the resin during polymerization.

This third method of observing strains, that is, by noting any dimensional changes in the denture under service conditions, is therefore indirect. The absence of dimensional changes does not indicate a strain-free denture, but only that the strains, if present, are not serious or that the service conditions are/were not such as to cause the strains to be relieved.

We have a denture here which was made 14 months ago. At body temperature (99°F.) it still shows excellent adaptation to its cast and to an index of the occlusal and incisal surfaces of its teeth.

4. Immersion in solvents

Active strains, particularly those around porcelain teeth, are revealed by immersion in a solvent (even in ethyl

* Tylman, S.D., and F.A. Peyton. "Acrylics and Other Dental Resins".

National Bureau of Standards, Circular C 433 - "Physical Properties of Dental Materials"

Skinner, E.W. "The Science of Dental Materials"

alcohol, which is a poor solvent for methyl methacrylate) in the form of crazing.

In the literature we found a reference to polishing dentures by means of solvent vapors.* This idea was not new here as it had been suggested in the first report of this investigation.

However, in the few attempts which we have made to polish dentures by solvent vapors, for example, with ethyl acetate, the result was always an extensive crazing of the entire denture surfaces and particularly those areas around the teeth. When plastic teeth were used, these teeth themselves were severely crazed.

Since solvents have such damaging effects on processed dentures, it is advisable to keep solvents, in any form, away from them.

Study of the Polymerization Reaction

(a) Preliminary Experiments

Numerous experiments were made to learn as much as possible about the polymerization reaction. In general, it was found that the more rapid the cure, the higher was the peak temperature. We became convinced that to produce satisfactory dentures it would be necessary to control this exothermic reaction by reducing or eliminating the sudden evolution of heat. Several possible methods suggested themselves.

(b) Catalysts

The rate of polymerization of methyl methacrylate is increased by heat, by light and peroxide catalysts. Conversely, the rate is reduced or polymerization even inhibited by anti-oxidants such as hydroquinone.

We investigated the use of hydroquinone to slow down the reaction by adding this compound to the monomer used in the powder-liquid mixture. It was found ineffective because although the time to reach the "kick-over" point was prolonged, the peak temperature was not reduced.

* Leader, S.A. Brit. Dent. J. 79, 183. 1945.

(c) Use of Metal Powder in the Investment

The thermal conductivity of the investment can be increased by incorporating in it a finely divided metal powder such as aluminum. This would serve to conduct away the heat of polymerization more quickly than plaster alone.

These facts were confirmed by our studies which indicated that when polymerization occurred the peak temperature was reduced. We also found it possible to speed up the rate of curing and reduce porosity. However, the use of aluminum powder at our disposal had two disadvantages: (1) a very fine aluminum powder produced a weak investment and (2) a smooth mold could not be made when a relatively coarse (30 mesh) powder was used.

(d) Thermoduets

In some of our early experiments we cured several circular plates of denture base material in a heated hydraulic press. The steel molds were fitted with thermometer wells which were very close to the resin but we could detect no rise in temperature on polymerization. Evidently the metal molds conducted the exothermic heat away as rapidly as it was evolved. This was the first indication that some success might be attained in controlling the reaction by means of thermoduets--metal inserts in the investment material. Figure 4 shows a cross-section of a dental flask with two thermoduets in the investment. This is the arrangement which was found to give the most satisfactory results.

Thermoduets have been advocated and used in the past in the tooth-half of the investment but we believe that they have not been used in the artificial stone cast for the purposes of thermal conductivity.

(e) Heating Cycle

In preliminary experiments it was noted that the peak temperature could be reduced somewhat by cooling the flask and the denture material just before the rapid evolution of heat took place. We were further convinced that a suitable cure could be worked out on this basis when we found in the dental literature* a curing technique which in-

* Kelly, E.B. Dental Digest, 49, 102. 1943. 49, 170. 1943.

volved cooling of the denture base material as one of its stops.

From our results it appears that if the denture material is heated to incipient rapid polymerization, cooled and then completely polymerized, any peak temperature which may occur is not liable to cause porosity as it would normally do in a rapid curing method.

Thermoduct Technique

Using two thermoducts in the mold, the following curing cycle was developed. The dental flask is immersed in water at 120°F. and is heated over a period of 15 minutes to about 170°F. The heating bath is then replaced with cold tap-water and the heating continued at the same rate up to 212°F. This will require about 25 to 30 minutes. At this time the curing may be stopped and the flask allowed to bench-cool for 20 minutes. When the flask has been further cooled in cold water for about 5 minutes, it may be opened and the denture completed.

Figures 5 and 6 are presented to show the effects of the thermoducts. Figure 5 shows the thermal effects, recorded by thermocouples in clear denture base material, when only one thermoduct is used. Polymerization proceeds uniformly through the mass of the resin until at 185°F., the temperature in the thick region of the flange increases rapidly to 237°F. This peak did not produce any porosity, but it was our endeavor to eliminate such local thermal effects on the theory that they would cause local differences in degree of polymerization of the resin and would therefore be liable to produce undesirable internal strains.

Figure 6 shows a similar case when an additional thermoduct is present in the artificial stone cast. In this instance, no peak occurs and all parts of the resin have cured at the same rate. In both examples, the polymerization was completed in less than one hour, effecting a considerable saving in processing time. Figure 7 is a photograph of a clear denture made by the thermoduct method, showing no evidence of porosity.

Transverse Strength

The test for transverse strength in the Tentative American Dental Association Specification No.12 was used to ascertain if the thermoduct method as outlined above would produce a satisfactorily cured denture base material. This test ensures that the denture is properly cured and that it is tough without being too flexible or too brittle. Since Lucitone is accepted by the A.D.A. as a satisfactory denture base material when properly used, the transverse strength test can be used to check the suitability of the thermoduct curing method.

The specification requires that the denture base material specimens (2.50 x 10.0 x 65 mm. in dimensions) shall show a deflection of less than 2.6 mm. at a load of 4000 grams, a deflection between 3 and 8 mm. at 6000 grams and the maximum load shall be at least 6000 grams.

Figure 8 accompanying this report is a diagram of the apparatus used in making the test. Figure 9 is a graph showing the results of tests made on material cured by four different methods. Cure 1 is the thermoduct method. It passes the specification limits and is therefore a satisfactory curing method. Cure 2 is also the thermoduct technique but with the heating prolonged at 212°F. A comparison of these two curves shows that there is no important advantage to be gained by prolonged heating at 212°F. with the exception of a slightly higher maximum strength. Cure 3 was once suggested by a commercial manufacturer of denture base materials and then withdrawn as inadequate. Cure 4 is that used by the Canadian Dental Corps with the heating at 212°F. reduced from 45 to 15 minutes. It is a satisfactory method on the basis of transverse strength.

Practical Cases

The thermoduct method was worked out on a research scale. All dentures were made on a standard sized case, so that only one size of thermoduct was required for all cases. In the making of practical dentures for patients, these ideal conditions would not be present and, in addition, there would conceivably be entirely different methods of procedure in making a finished denture. Therefore, with the cooperation of members of the Faculty of Dentistry at the University of Toronto and Mr. F.T. Wood, an undergraduate dental student

and experienced technician, a practical research program was carried out and a number of dentures made for actual service.

Thermoducts

The necessary thermoducts for insertion in the stone casts were designed by taking measurements of a number of model casts in a collection at the Dental College of the University of Toronto. The important dimensions such as depth of vault, distance between ridges, etc., were measured and a good indication obtained of the average dimensions. With the aid of these measurements, several thermoduct models were made for both upper and lower dentures and then cast in bronze. The bases of the thermoducts were polished flat so that they would make good contact with the bottoms of the dental flasks and thus provide the maximum thermal conductivity.

As work progressed, it was found necessary to make a few minor changes in the designs of the thermoducts. Thermoducts for lower dentures had not been made high enough to ensure that, when properly inserted in the denture cast and invested in the lower half of a dental flask, the land of the investment was approximately horizontal and level with the rim of the flask. Several brass plates were designed to be attached to the bottom of the thermoducts to permit the adjustment of the thermoducts to various desired heights. In addition, some of the plates were made with their top and bottom surfaces at slight angles to each other so that the denture could be invested at an angle which would facilitate deflasking. These details are shown in Figure 10. In practice, it was found that one plate of the correct height and/or pitch was adequate for most cases.

Figure 10 also shows a thermoduct for an upper denture. These had to be modified by cutting a trough or undercut near the base on all sides, so that the cast and thermoduct could be mounted securely on an articulator bow by means of the plaster used for that purpose. Also, for purposes of remounting to check the articulation of the teeth of a finished denture, two holes were counter-sunk in the bases of the thermoducts. In our work these holes were not used because a different method of remounting, making use of an occlusal index, was used.

It was found that it is an easy and accurate step to position the thermoducts in the artificial stone cast if

the impression was not boxed. We believe that most commercial dental laboratories do not box their impressions. However, members of the local dental committee pointed out that boxing ensures that the periphery of the impression is preserved, so we followed this safer procedure in pouring the casts for the practical dentures.

Figures 11 and 12 show respectively photographs of a lower thermoduct and its spacing plates and an upper thermoduct.

Full Dentures

In the limited time available, we were able to complete five full upper dentures and two full lowers by the thermoduct method as well as one upper and three lowers by the method used at the Dental College of the University of Toronto. Where a complete set of dentures was being made for a patient, we processed one by the thermoduct method and the other by the Dental College method in order to compare the technique and the results in each case.

In the thermoduct method, it is important to use a thermoduct in the cast of the correct size and shape. When this is done, it is relatively easy to insert the thermoduct while the cast is being poured in the impression material. The remaining steps in the procedure for making a denture are then quite straightforward. The range of sizes of the thermoducts which were used, having dimensions which were averages of those measured from specimen casts, varied sufficiently in size and shape to be entirely adequate for the dentures which were made.

It is particularly important to choose a thermoduct of the correct dimensions for a lower denture. Unless the thermoduct fits well and can be inserted in the cast so that it comes close to the bearing surface, an unusually high cast results. It may then be too large to mount accurately on an articulator. Fortunately, the design of the lower thermoducts permits the lower spacing plate to be removed to facilitate articulator mounting. This plate can be replaced when the denture is to be processed.

Photographs were made of a number of the dentures which were processed to show the shapes which were successfully handled and the texture of the finished dentures. Figures 13

and 14 are two photographs of the same denture which was made by the thermoduct method and Figures 15 and 16 are also two views of another denture made by this method. Figures 17 and 18 are photographs of other dentures made by this technique, showing the general shape of the cases.

Figures 19 and 20 compare the external appearance of pink methyl methacrylate denture base material when properly cured and when unsatisfactorily processed. The speckled surface is caused by the red pigment surrounding the original polymer (powder) particles and is emphasized in these pictures because the photographic film was especially sensitive to red. In Figure 19 there is no evidence of porosity while in Figure 20, the deep pits in the ridge of the denture and at the base of the first molar, are the severest form of porosity and were formed when this case was processed too rapidly.

Partial Dentures

In addition to the full dentures, two partial dentures were successfully made by the thermoduct technique.

In the pouring of stone casts for partial dentures where the impressions have been taken with a hydrocol impression material, such as Zelex, care should be taken to see that the important features, for example, the abutment teeth and the tissue surfaces, are not distorted by the weight of the thermoduct. This can be done by pouring a small amount of stone on to these surfaces and allowing it to set before pouring the rest of the cast and inserting the thermoduct. This procedure is sound practice even when a thermoduct is not used.

Photographs of a partial lower denture which was made by the thermoduct method are shown in Figures 21 and 22 while Figure 23 shows a partial upper.

Evaluation of the Thermoduct Method

The thermoduct method was compared with the method used at the Dental College. This latter method did not make use of thermoducts and the heating cycle required one hour at 160°F., heating to 212°F. and one-half hour at 212°F. This cure is similar to one suggested by the manufacturers of the acrylic denture base material, Vernonite, and graphs of this curing cycle show that peak temperatures are developed in the resin during the period at 160°F.

The thermoduct method requires a little less than one

hour to complete the polymerization thus effecting a saving of 45 minutes to one hour of processing time. It eliminates porosity by controlling the polymerization reaction, provided the prescribed heating cycle is adhered to and the flask is properly packed. It also adds a safety factor by preventing local overheating and ensuring that all parts of the denture base material polymerize at the same rate and presumably to the same degree of polymerization and, in cooling, it also prevents thermal inequalities. The thermoducts therefore tend to minimize internal strains. As far as external appearances are concerned no difference could be detected between practical dentures made by the thermoduct method and those made by the Dental College method.

The writer's assistant, Mr. Wood, who has had considerable experience in making dentures noted that the presence of thermoducts in the cast made deflasking much simpler in that the relatively thin layer of artificial stone could be easily separated from the denture. In his opinion, this fact was also a distinct advantage of the thermoduct method. In some cases where no thermoducts are used, it is very difficult to remove the cast and considerable care is necessary to avoid damaging the denture.

Distortion Caused by Repairing

The problem of repairs requires further study because in the methods currently used some distortion usually occurs. Our experience has shown that some internal strains are present in a denture no matter what method is used to process it. These strains are of no significance unless the denture is subjected to a high temperature for some time. Therefore it is best to make repairs at the lowest possible temperature. The usual method of repairing at 160°F. for several hours will cause a distortion of approximately 1/2 of 1 per cent. Repairing at 212°F., we have found, will distort the denture by more than 1 per cent.

We have some preliminary results which indicate that it may be possible to make a satisfactory repair at much lower temperatures than 160°F. and avoid distortion. As before, one requisite will be that the repair material must have adequate strength. In view of the close connection of this subject to that of making dentures we hope to complete a study of it very shortly and report the findings as a supplement to this report.

Separating Media

In the past tinfoil was used widely as a separating medium between the denture base material and the plaster mold surfaces. It cannot be denied that it is a very effective separator imparting as it does a smooth, glossy surface to the denture. However, even a skilled worker has difficulty in avoiding wrinkles in the foil and the task of applying it is tedious.

Sodium silicate or water-glass has also been used for some time and is effective and suitable for pink dentures. In some cases, however, it is difficult to apply it to a stone cast satisfactorily because, in the boiling-out process, the wax or base plate material has adversely affected the surface.

We have used cellulose triacetate and ethyl silicate with some success but in our practical work we discovered that it was necessary to keep this separator away from the surfaces of the teeth to avoid the occurrence of spaces between the teeth and the plastic.

Lately we have used a 2 per cent solution of sodium alginate in water, preserved with sodium benzoate. This separator gave highly satisfactory results when used for pink dentures. It caused no spaces if accidentally applied to the surfaces of teeth and produced a smooth surface on the plastic. It was used on all surfaces of the mold and the fact that there were no wrinkles materially reduced the amount of grinding and polishing.

Summary

This report summarizes the investigations conducted at the Ontario Research Foundation on methyl methacrylate denture base materials.

Some physical properties of methyl methacrylate are described and some problems connected with the making of dentures are discussed.

A thermoduct method for the rapid processing of dentures is presented. This method reduces the time necessary to cure a denture, controls the polymerization reaction by avoiding local overheating and eliminates porosity if the

prescribed instructions are followed.

It was found that trial-packing cannot be eliminated conveniently, but with experience and by using the proper technique, the number of flask closures can be reduced to a minimum.

Shrinkage is discussed and it is shown that polymerization shrinkage is counter-balanced by expansion due to water adsorption so that the difference or net linear shrinkage is unimportant from a practical viewpoint.

It was discovered that polishing by chemical methods should be avoided as solvents for the denture base material produce serious crazing.

In this report we have described our investigations with one type of methyl methacrylate denture base material and we have presented a method for using it by a compression molding technique. There are other molding methods and other types of denture base materials with new ones being made available from time to time. Among the alternative materials are the following:

Luxene 44, a vinyl copolymer-acrylic compound, which is stated to have less curing shrinkage and greater impact strength; Densene 33, a denture base material of several polymers including methyl methacrylate which is said to give greater accuracy in fit and to have better dimensional stability than other resins. Some dentists are of the opinion that the use of styrene in denture bases also gives greater accuracy than methyl methacrylate alone.

We are keeping in touch with information of this kind as it becomes available and will keep the committee informed of any significant developments in this field.

September 24, 1947.

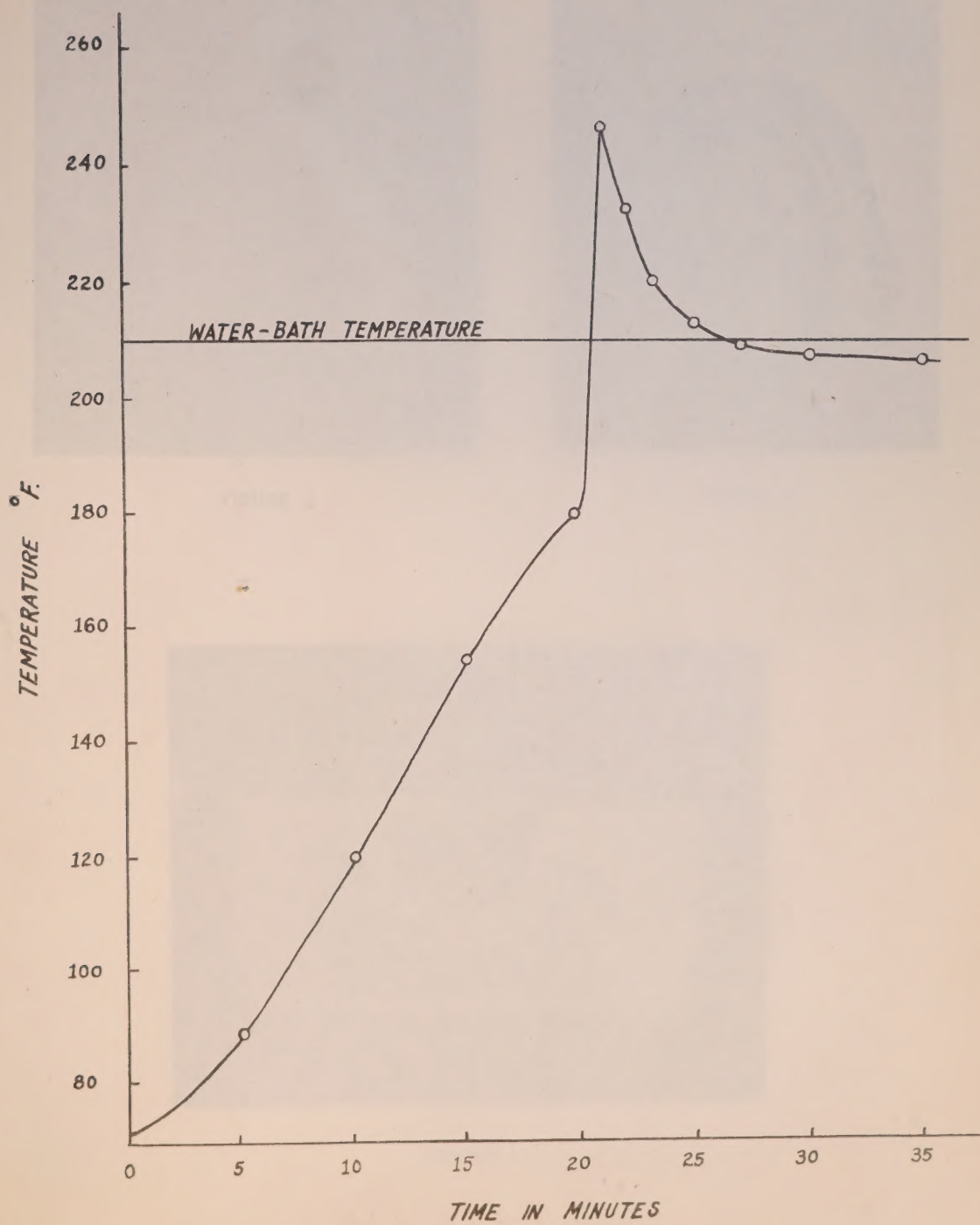


Figure 1

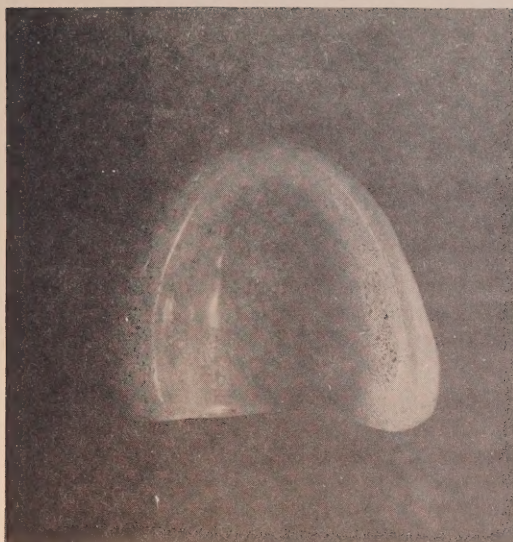


FIGURE 2

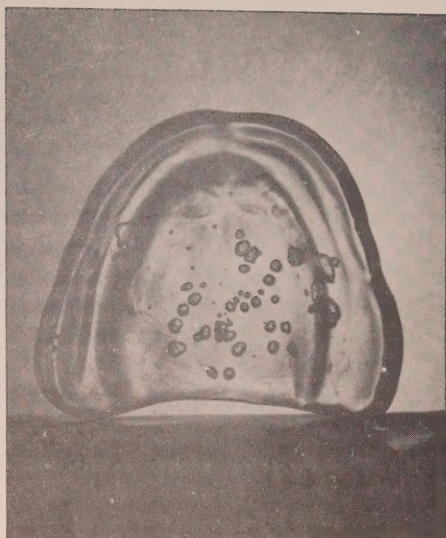


FIGURE 3

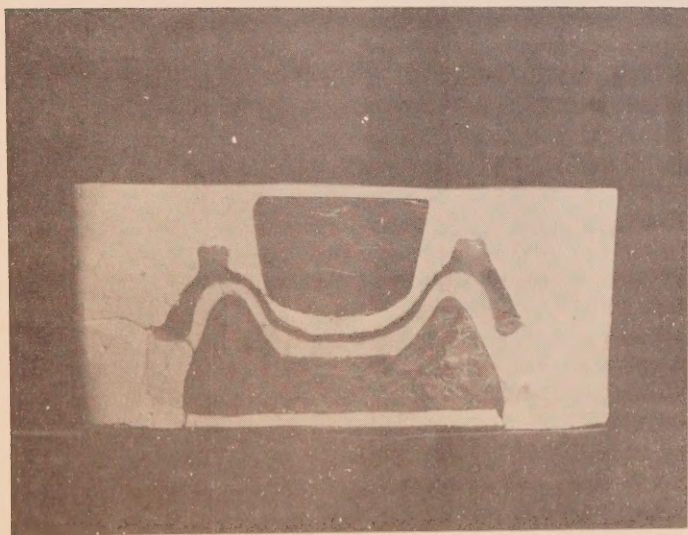
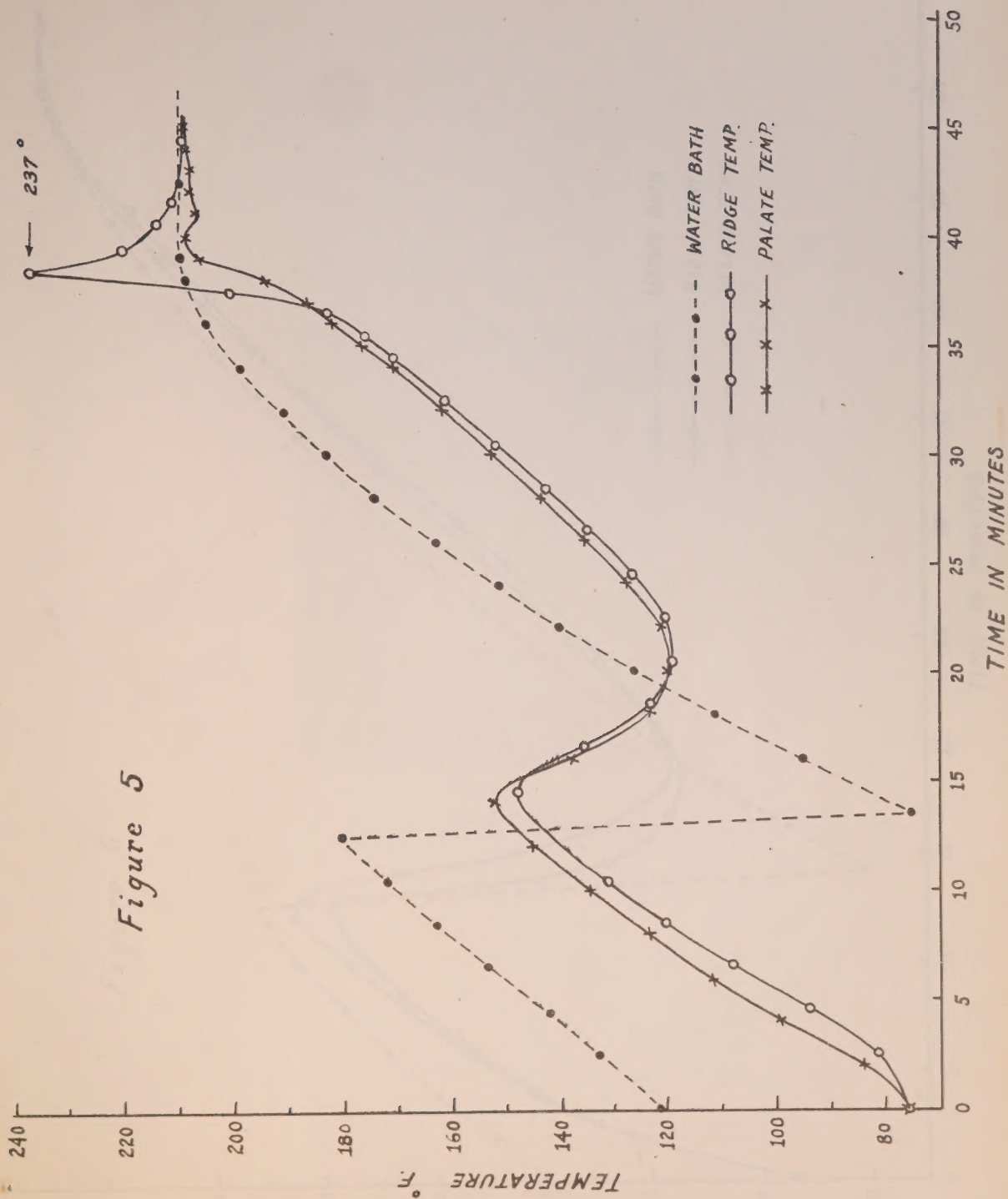


FIGURE 4

Figure 5



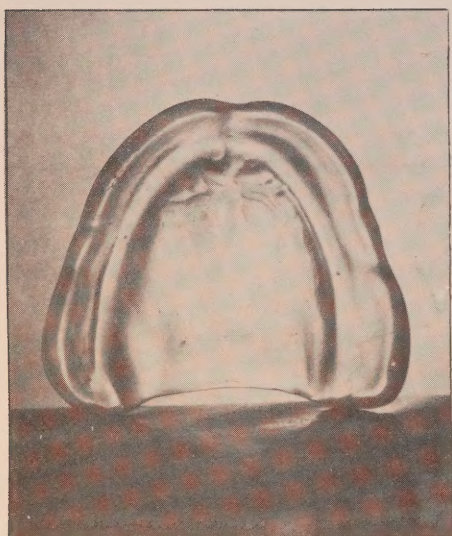


FIGURE 7

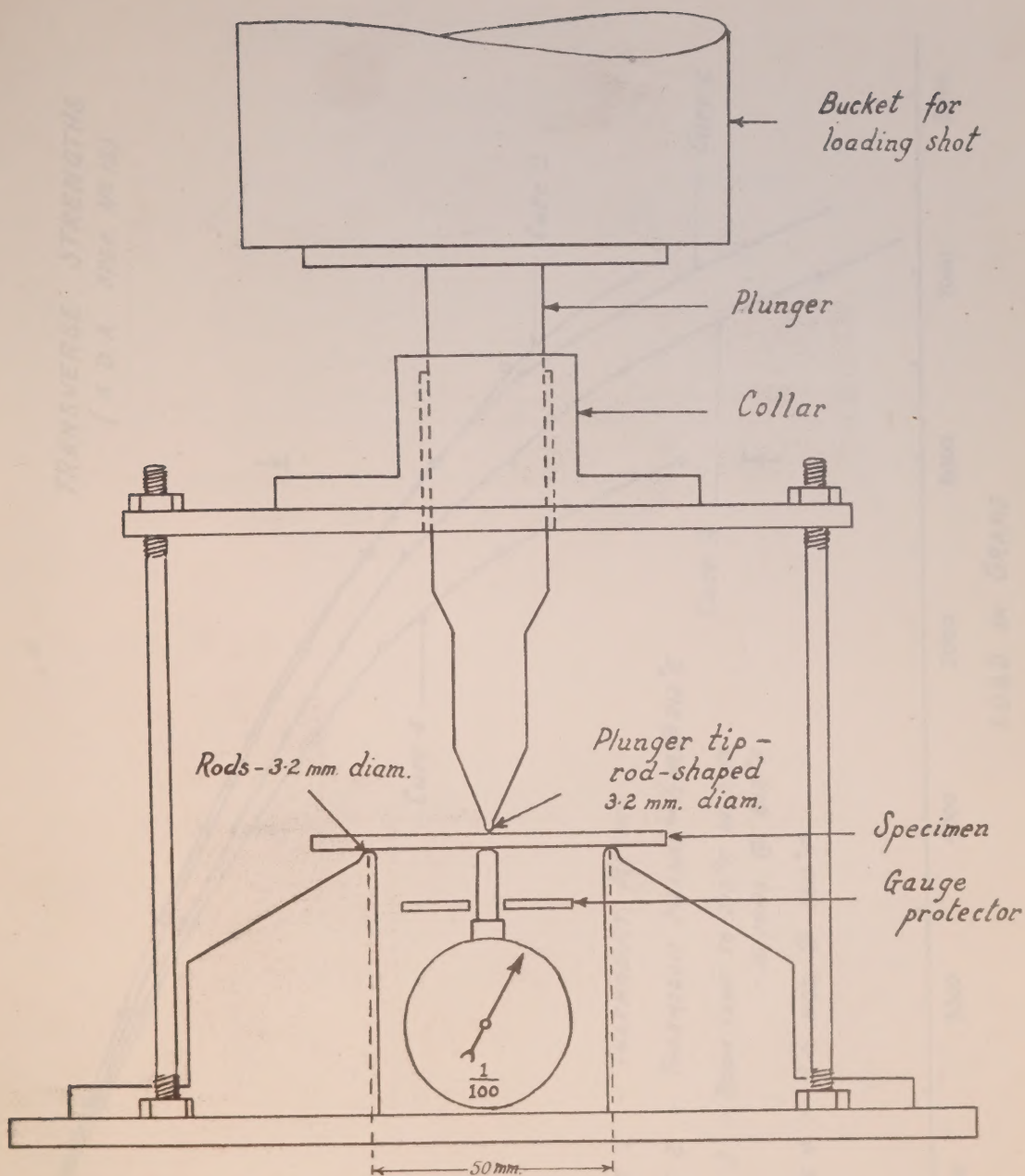


Figure 8

TRANSVERSE STRENGTHS
(A.D.A. SPEC. No 12)

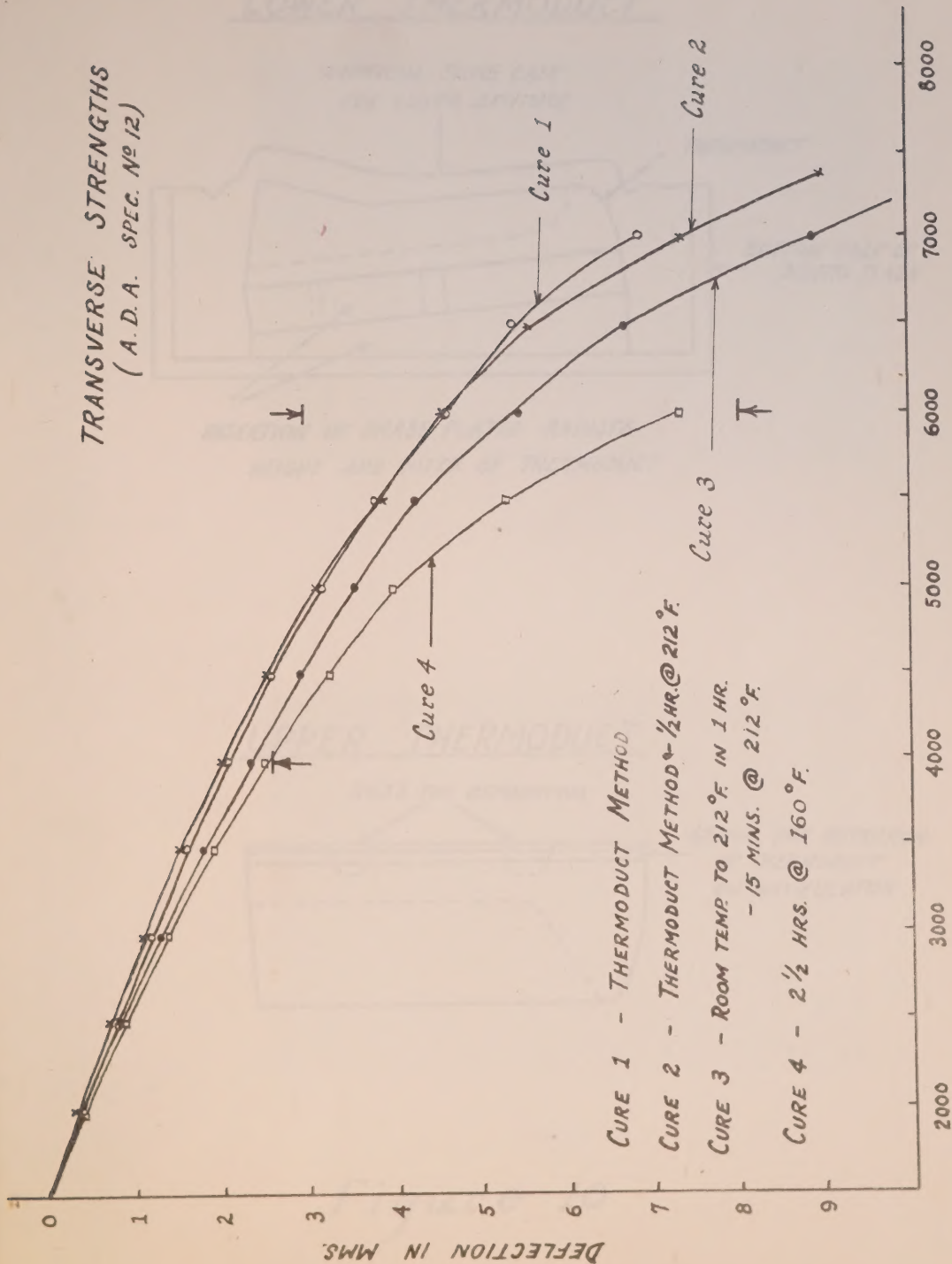
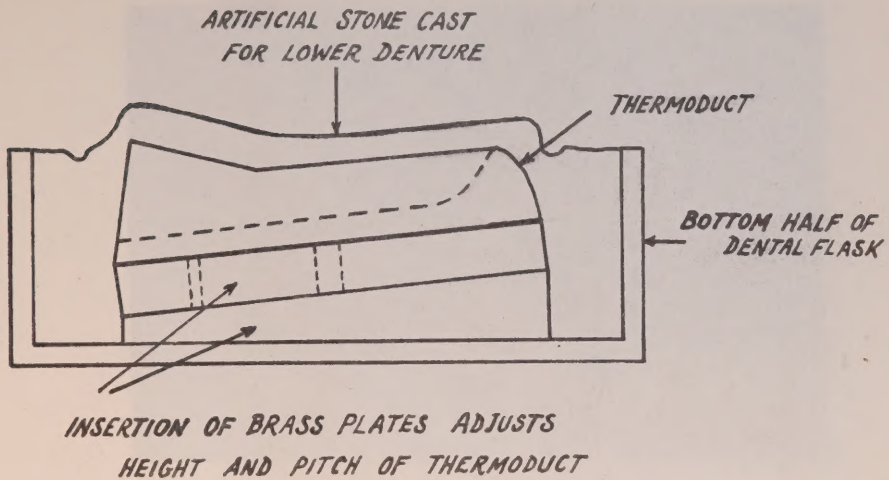


Figure 9

LOWER THERMODUCT



UPPER THERMODUCT

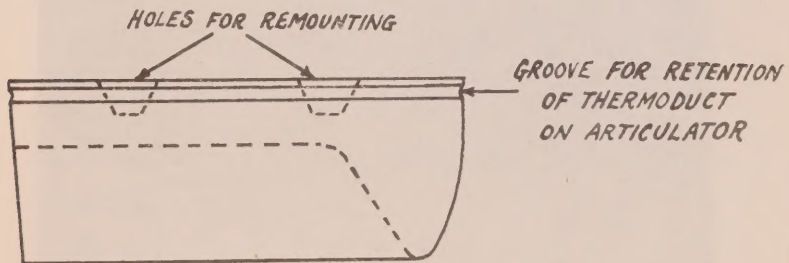


Figure 10

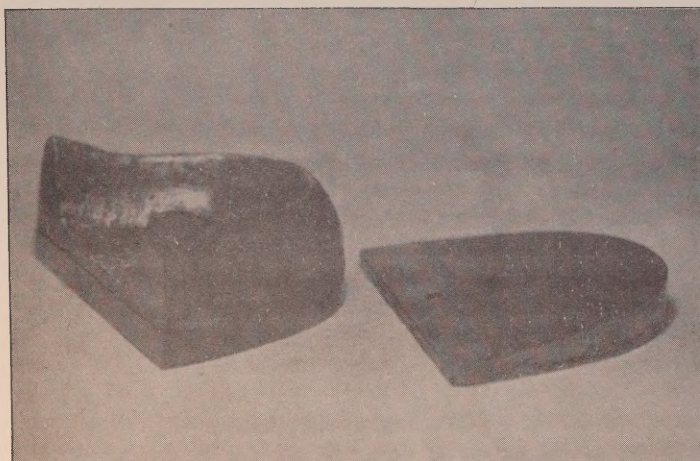


FIGURE 11

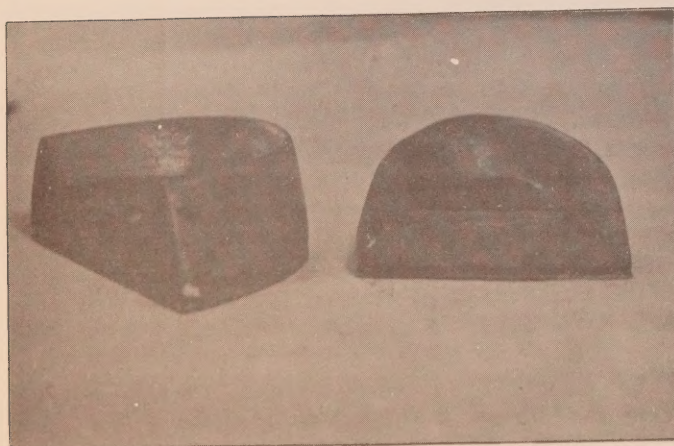


FIGURE 12



FIGURE 13

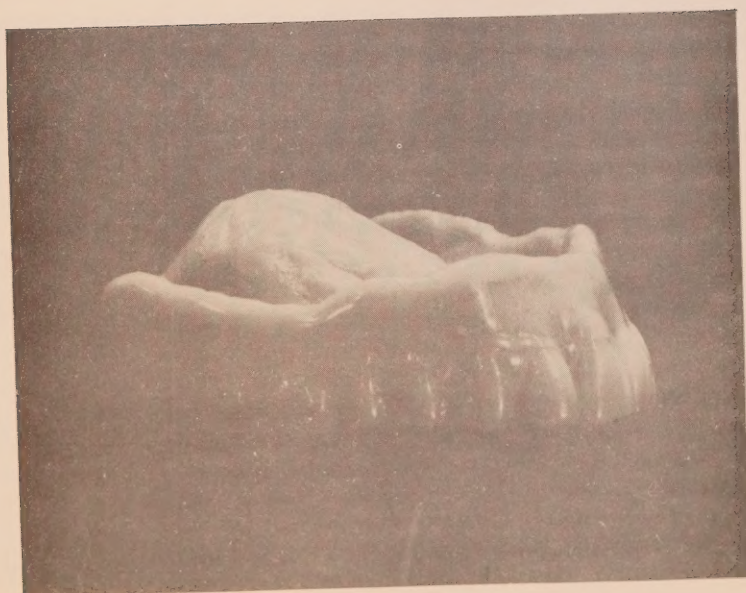


FIGURE 14

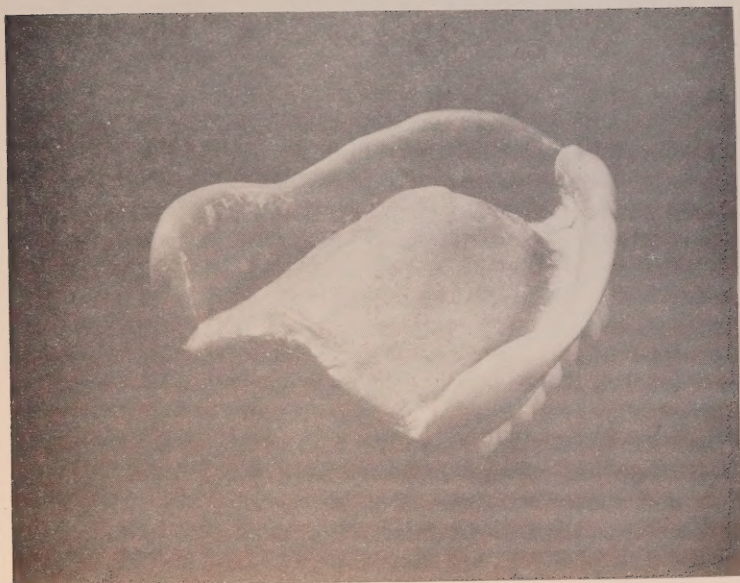


FIGURE 15



FIGURE 16



FIGURE 17



FIGURE 18

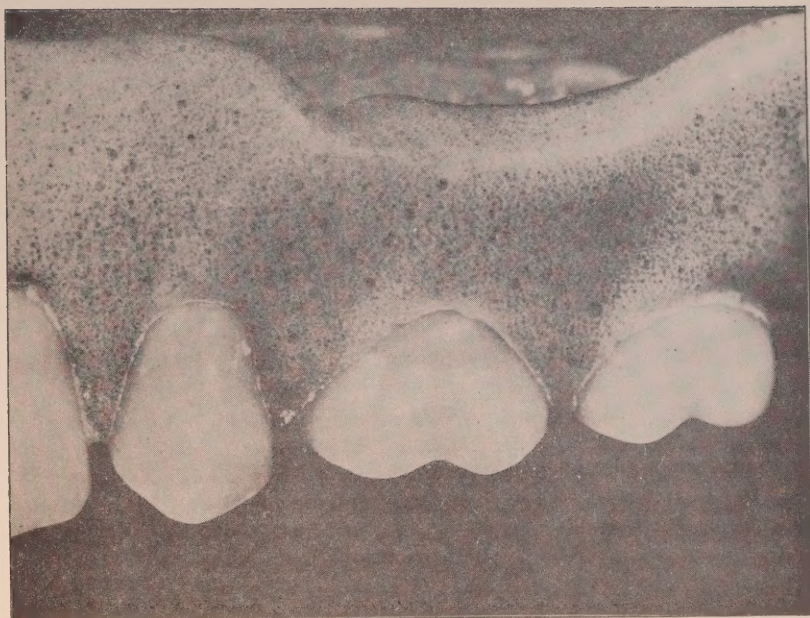


FIGURE 19

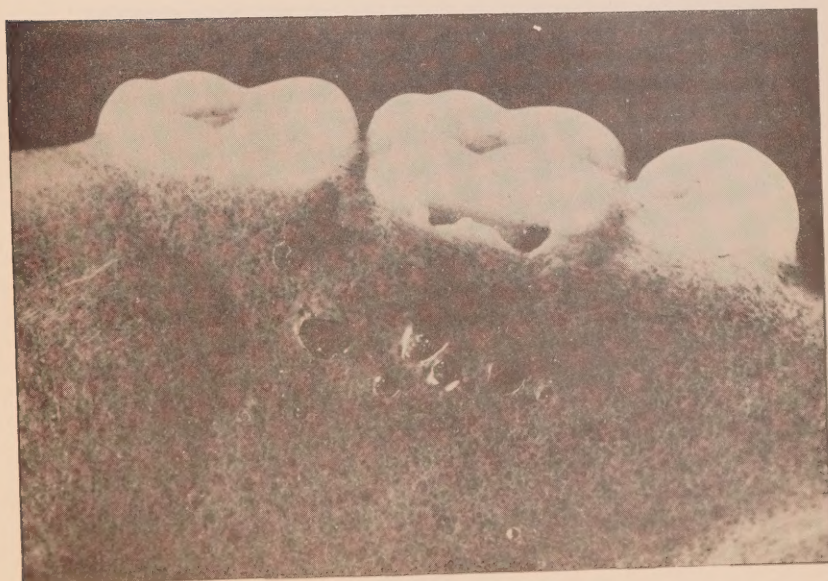


FIGURE 20

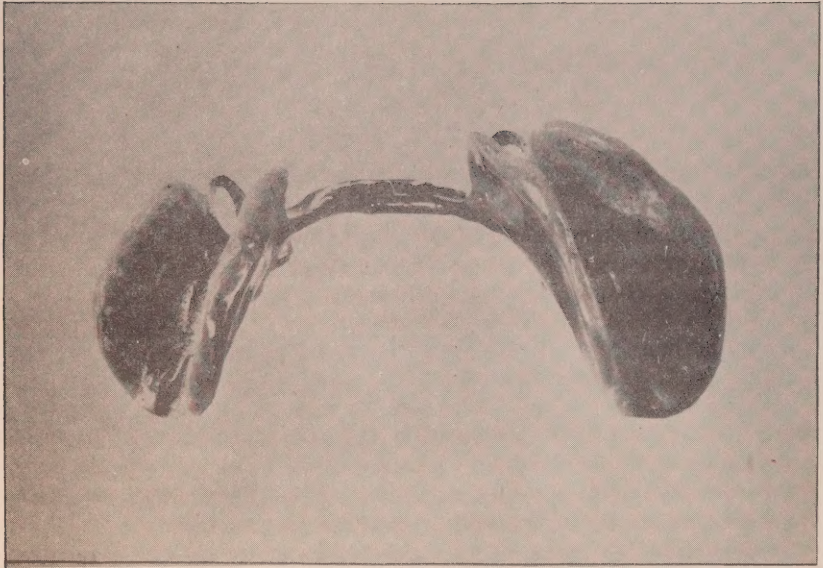


FIGURE 21

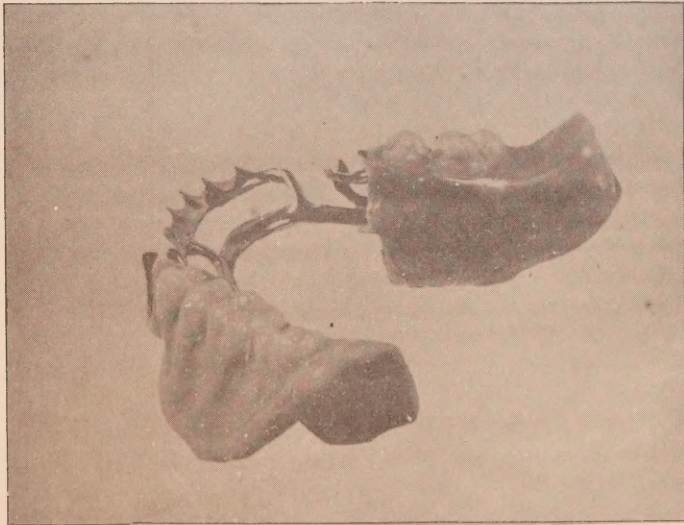


FIGURE 22



FIGURE 23

APPENDIX " B "

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: An investigation of the chemical mechanisms involved in decrease of dental caries by fluorides.

Grantee: J. J. Rae

Project No. DR 1

Amount of Grant: \$1000.

SUMMARY OF WORK

Since our last report a group of salivas has been examined to see if there is a relationship between the caries susceptibility, as measured by the lactobacillus count and the organic phosphate concentration. The average mg % organic phosphate for 12 salivas with a lactobacillus count of less than 1000 was 1.02 whereas for 12 salivas with a lactobacillus count of over 30,000 it was 0.08%.

The phosphoric esters in saliva hydrolyse to inorganic phosphate in 72 hours. This hydrolysis may be completely inhibited by the addition of 50 p.p.m. of sodium fluoride. A comparison of the rates of enzymatic hydrolysis by rabbit bone phosphatase of the esters in saliva and glycerophosphate would indicate that these substrates are not the same.

Unsuccessful preliminary experiments attempting to corroborate the work of Kessel et al. (J.A.D.A. 33, 695, 1946) on the effect of ammonium salts on acid production in saliva have been undertaken and this work is being continued.

Date: October 1, 1947.

A P P E N D I X " B "

INTERIM REPORT NO.4 ON D.R.-1

THE CHEMICAL MECHANISM OF DENTAL CARIES

Period Covered - Feb. 1 - June 30th.

Research Workers - James J. Rae
Charles T. Clegg
Muriel I. Davies

Institution - Department of Chemistry,
University of Toronto

Since our last report two papers (I & II) have been submitted for publication to the Journal of Dental Research. Copies of each of these papers are enclosed.

(A) The Effect of Various Inorganic Salts on the Solubility of Calcium Phosphate, Tooth Enamel and Whole Teeth in Lactic Acid.

This paper is an extension of the work published in the Journal of Dental Research, Vol. 24, p. 235, 1945.

(B) Changes in the Calcium and Phosphate Concentrations of Salivas and Inorganic Salt Solutions on Shaking With Calcium Phosphate.

This paper is a reply to Karshan's publications (J.D.R. 15, 383, 1936 and J.D.R. 18, 395, 1939) in which he states that caries-immune and caries-susceptible salivas may be distinguished

by the differences in amounts of calcium and phosphorus precipitated or adsorbed on shaking the salivas with calcium phosphate. We found that a decisive factor in the changes of concentration observed was the pH of the solutions.

The third enclosure(III) is a final report of the work of Miss Davies who left at the end of the academic year.

Most of the work contained in Miss Davies report was included in Interim Report No. 3 on D.R.-1. But the following work was done after Report No. 3 was submitted.

Systematic analysis of 50 salivas was undertaken. The total phosphate, inorganic phosphate and organic phosphate fractions were determined as well as the volume of precipitate produced on centrifuging; the pH; the calcium concentration; the number of decayed filled and missing teeth and the lacto bacillus count.

There seems to be slightly less organic phosphate in the caries-susceptible salivas than in the caries-immune salivas. Hydrolysis of the esters during collection or during the interval between collection and analysis was prevented by the addition of sodium fluoride.

A preliminary study on the hydrolysis of the phosphoric esters in saliva was also made and the results are incorporated in this report. These esters do not hydrolyse at the same rate as glycerophosphate and in some cases the organic phosphate rose above the initial reading which would seem to imply a synthesis rather than an hydrolysis.

In addition to the material described in these three enclosures the following investigations were carried out.

In a paper published by Kesel et al (Journal American Dental Assoc. 33, 695, 1946) a striking difference between caries-susceptible and caries-immune salivas was described. Immune salivas, it was stated, develop on incubation an inhibitory factor for the growth and acid production of lactobacillus. Ammonium salts are regarded as the responsible material. In an attempt to repeat these results we have so far been unsuccessful but intend to continue this investigation.

An improved fluorine determination (Armstrong, Jour. of Ind. & Eng. Chem. Vol. 8, p. 384) has been investigated and several experiments lead us to believe that it can be used satisfactorily in this research.

The effect of oxalates on bone phosphatase was investigated and it was found to have no inhibitory effect in low concentrations (up to 0.1%) and only a moderate inhibitory effect in concentrations up to 1% sodium oxalate.

PROPOSED WORK

1. To continue the research on salivary phosphatase and study the effect of various substances such as iodoacetate and vitamin K on its activity. To purify the enzyme and study its characteristics when acting on various substrates.

2. To investigate further the effect of ammonium salts on acid production in caries-immune and caries-susceptible salivas.

3. To improve the analytical methods for the determination of fluorine and calcium and Phosphorus in salivas and other solutions.

PROPOSED WORK

PAPER NO. I

THE EFFECT OF VARIOUS INORGANIC SALTS ON THE
SOLUBILITY OF CALCIUM PHOSPHATE, TOOTH ENAMEL
AND WHOLE TEETH IN LACTIC ACID

James J. Rae and Charles T. Clegg

Chemistry Department,
University of Toronto, Toronto, Canada.

(This work was aided by a Grant in Aid from
the National Research Council of Canada.)

Since our previous publication⁽¹⁾ further evidence in support of the mechanism proposed for fluorine action on teeth has been gained from experiments with barium nitrate, silver nitrate, silver fluoride and lead nitrate. All of these materials exhibited a "protective effect" on whole teeth suspended in lactic acid, and all reduced the "apparent solubility" of tooth enamel and tricalcium phosphate in lactic acid. In the case of lead nitrate and silver fluoride increases instead of decreases in the weight of residue were obtained, due no doubt to precipitation of lead phosphate and silver phosphate, both of which have greater molecular weights than the calcium phosphate being dissolved.

The suggestion made at that time to account for the protective effect of fluorine, i.e. that the tooth enamel is dissolved

in lactic acid and then the calcium reprecipitated as calcium fluoride, must now be widened so as to include any material which will precipitate insoluble calcium salts such as oxalates and, in addition, any material which will precipitate insoluble phosphates, such as barium, lead and silver salts.

A summary of the results obtained with these salts is given in Table I. The numbers in brackets refer to values obtained in control tubes.

In the experiments with barium nitrate there was a slight trace of decalcification.

TABLE I

THE EFFECT OF VARIOUS SALTS ON THE DECALCIFICATION OF TEETH, AND ON THE SOLUBILITY OF TOOTH ENAMEL AND TRI-CALCIUM PHOSPHATE IN 1% LACTIC ACID

Material Added	WHOLE TEETH		TOOTH ENAMEL		TRI-CALCIUM PHOSPHATE		
	Mg.P per 10 cc.	Mg.Ca per 10 cc.	Change in Weight Mg.	Mg.P per 10 cc.	Change in Weight Mg.	Mg.P per 10 cc.	Mg.Ca per 10 cc.
NaF	2.83	7.96	-25	3.34	-50	5.9	9.0
0.01M	(9.5)	(23.2)	(-50)	(5.6)	(-80)	(6.0)	(30.6)
(NH ₄) ₂ C ₂ O ₄	1.22	-	-36	7.0	-22	9.8	-
0.01M	(5.6)	-	(-65)	(5.0)	(-68)	11.6	-
Pb(NO ₃) ₂	0.78	3.83	+10	0.27	+66	0	11.9
0.05M	(5.3)	(25.9)	(-38.2)	(5.7)	(-67)	(8.72)	(28.5)
Ba(NO ₃) ₂	3.42	11.21	-16.2	2.40	-10.2	10.3	27.2
0.05M	(5.3)	(25.9)	(-38.2)	(5.7)	(-62)	(+1.6)	(26.8)
Ag(NO ₃) ₂	2.40	12.85	-12.1	2.11	-13.5	9.8	31.4
0.05M	(5.3)	(25.9)	(-38.2)	(5.7)	(-62)	(+1.6)	(26.8)
AgF	2.41	7.40	+8	7.5	+24	4.32	7.9
0.01M	(9.5)	(23.2)	(-50)	(5.6)	(-67)	(8.72)	(28.5)

Concentrated solutions of calcium salts and phosphates, when used in similar experiments, reduced the real solubility of tooth enamel as shown by phosphate analysis; but had little, if any, effect on the weight of residue in the tubes. Solutions containing 16 mg. %Ca and 10 mg. %P had a protective effect on teeth.

These results support our previous contention that any salt whose anions form an insoluble calcium salt (e.g. ammonium oxalate) or whose cations form insoluble phosphate salts (e.g. lead nitrate, barium nitrate) will protect the teeth and reduce the apparent solubility of tooth enamel and calcium phosphate.

(1) Rae, J.J. and Clegg, C.T., J. D. Res. 24, 235, 1945.

PAPER NO. II

CHANGES IN THE CALCIUM AND PHOSPHATE CONCENTRATIONS
OF SALIVAS AND INORGANIC SALT SOLUTIONS ON SHAKING
WITH CALCIUM PHOSPHATE

James J. Rae and Charles T. Clegg,

Chemistry Department,
University of Toronto, Toronto, Canada.

(This work was supported by a Grant-in-Aid from the
Associate Committee on Dental Research of the
National Research Council of Canada.)

The salivas from caries-susceptible and caries-free individuals show few chemical differences, and it would be an extremely useful clinical test if some decisive criterion to distinguish between these two types of salivas were available.

Karshan⁽¹⁾⁽²⁾ has stated that although the mg.% calcium and mg.% phosphorus are the same in salivas from both caries-free and caries-active individuals, the change in the concentration of these ions produced by shaking the salivas with excess powdered tri-calcium phosphate is remarkably different. In stimulated salivas from caries-free individuals 65% of the calcium and 20% of the phosphate was removed by shaking with tri-calcium phosphate, whereas salivas from caries-immune individuals had 39% of the calcium and 45% of the phosphate removed by the same treatment.

These surprising results prompted us to investigate this phenomenon further in an attempt to gain some insight into the chemical processes involved.

On shaking salivas with tri-calcium phosphate (Kahlbaum's Reagent) we were unable to observe any decrease in phosphate but did obtain varying decreases in the calcium concentration.

When an aqueous solution of calcium nitrate and sodium phosphate of approximately the same calcium and phosphorus concentrations as saliva was used, an analogous effect was observed, viz. an increase in phosphate and a decrease in calcium. These results are tabulated in Table I. The final pH of the solutions was approximately 5.60.

TABLE I

THE EFFECT OF SHAKING WITH TRI-CALCIUM PHOSPHATE ON
THE CALCIUM AND PHOSPHATE CONCENTRATIONS OF SOLUTIONS

Solutions used	Before shaking		After shaking		Change Produced	
	P mg. %	Ca mg. %	P mg. %	Ca mg. %	mg. % P	mg. % Ca
Saliva	13.0	9.75	31.4	2.89	+18.4	-6.86
Calcium Nitrate Sodium Phosphate	12.6	8.4	18.2	2.6	+5.6	-5.8

Karshan has suggested that the ratio of Calcium to Phosphorus in the calcium phosphate used has an important bearing on the results obtained. To investigate this we prepared a series of calcium-phosphate mixtures made from calcium triphosphate and calcium diphosphate and shook these with solutions of calcium and phosphate approximating the composition of saliva. The Ca/P ratio of the Kahlbaum's tricalcium phosphate was found to be 2.10 and of the Kahlbaum's calcium diphosphate 1.45. The results are shown in Table II. The composition of the solution was 8.42 mg.% Calcium and 13.1 mg.% Phosphorus.

TABLE II

THE EFFECT OF SHAKING WITH TRI-CALCIUM PHOSPHATE
ON THE CALCIUM AND PHOSPHATE CONCENTRATIONS

Weight ratio Ca/P of solid used	Calcium		Phosphates	
	Final mg. %	Change produced mg. %	Final mg. %	Change produced mg. %
1.45	2.85	-5.57	11.7	-1.4
1.59	2.96	-5.46	22.0	+8.9
1.76	3.60	-4.82	26.4	+13.3
2.10	2.15	-6.27	21.8	+8.7

These results indicate that in all cases except for calcium diphosphate ($\text{Ca/P} = 1.45$) the phosphorus rose to about twice its original value and the calcium decreased to 40% of its original value. With the exception of calcium diphosphate changes in Ca/P ratio seem to have little effect on the results. Even with calcium diphosphate the change in phosphorus produced was almost within experimental error.

Another possible explanation of the results shown in Table I (i.e. an increase in phosphate and a decrease in calcium) may be found in the pH of the resulting solutions. For example, on shaking the calcium phosphate and calcium diphosphate with sodium acetate-sodium veronal buffer solutions at different pH's, the following results were obtained.

TABLE III

THE EFFECT OF PH ON THE SOLUBILITY OF TRI-CALCIUM
PHOSPHATE AND DI CALCIUM PHOSPHATE IN BUFFERED
SOLUTIONS

pH		Tri-Calcium Phosphate $\text{Ca}_3(\text{PO}_4)_2$			pH		Calcium hydrogen Phosphate CaHPO_4		
INITIAL	FINAL	Ca mg. %	P mg. %	Ca/P by weight	INITIAL	FINAL	Ca mg. %	P mg. %	Ca/P by weight
4.50	5.50	33.3	19.6	1.70	4.60	6.47	38.0	26.0	1.46
5.05	5.28	16.6	13.9	1.19	5.24	6.72	19.5	13.0	1.50
5.70	5.53	9.6	10.6	0.91	5.90	7.10	7.6	7.0	1.08
7.48	6.59	1.1	12.3	0.089	7.46	7.62	3.6	6.2	0.61
8.40	7.15	0.55	13.9	0.004	8.22	7.72	1.6	15.7	0.09

The fact that these buffer solutions, when shaken with calcium phosphates, do not yield solutions with theoretical Ca/P ratios ($\text{Ca}_3(\text{PO}_4)_2 = 1.94$ and $\text{CHPO}_4 = 1.29$) suggests that the CaO and P_2O_5 components of these compounds dissolve independently, and that the ratio of Ca/P obtained and the amounts of calcium and phosphate dissolved depends upon the final pH of the solution. The amounts of calcium dissolved in both these experiments decreased with increasing pH. The amount of phosphate dissolved passed through a minimum between pH 5 and 7.

The results of shaking solutions containing calcium and phosphate with tri-calcium phosphate at varying pH's showed that at a final pH of 4.95 both the Ca and P increased, but at a final pH of 7.60 the Ca dropped and the P increased. These results are shown in Table IV.

TABLE IV

THE EFFECT OF PH ON SHAKING SOLUTIONS CONTAINING
CALCIUM AND PHOSPHATE WITH TRI-CALCIUM PHOSPHATE

pH		Calcium mg. %		Phosphorus mg. %	
INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
4.52	4.95	8.04	41.1	16.5	36.0
5.20	5.25	8.04	24.4	16.5	34.4
6.65	5.78	8.04	9.26	16.5	30.0
7.40	6.32	8.04	2.19	16.5	25.5
8.50	7.60	8.04	0.84	16.5	27.0

When the pH of saliva was adjusted with HCl or NH_4OH , and then shaken with tri-calcium phosphate, the following results were obtained.

TABLE V

THE EFFECT OF PH ON THE CHANGES IN CALCIUM AND PHOSPHORUS
PRODUCED BY SHAKING SALIVA WITH TRI-CALCIUM PHOSPHATE

pH		Calcium mg. %		Phosphorus mg. %	
INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
3.97	4.75	11.76	35.2	10.6	40.5
5.60	5.38	11.76	11.3	10.6	30.0
7.40	6.30	11.76	2.22	10.6	34.5

These results show that at a final pH of 4.75 the calcium and the phosphate values both increased on shaking with calcium phosphate, whereas at a higher final pH (6.30) the calcium decreased and the phosphate increased.

SUMMARY AND CONCLUSIONS

Saliva and inorganic salt solutions containing comparable amounts of calcium and phosphate, when shaken with tri-calcium phosphate, yield solutions with higher phosphate concentrations and lower calcium concentrations than the original solutions.

When buffers, ranging in pH from 5.5 to 7.15, were shaken with tri-calcium phosphate, the amounts of calcium and phosphate dissolved had no apparent relation to the amounts of calcium and phosphate in the solid. The calcium values obtained decreased continuously with increasing pH; the phosphate passed through a minimum at pH 5.5.

Inorganic salt solutions containing calcium and phosphate, when shaken with calcium phosphate, showed an increase in both calcium and phosphate at a low pH, but at a higher pH the calcium decreased and the phosphate increased. Analogous results were obtained with saliva.

These experiments lead us to conclude that variations in concentration of calcium and phosphate of salivas, produced by shaking these salivas with calcium phosphate, bear little if any relation to the Ca/P ratio of the calcium phosphate used. The pH of the saliva or solutions used seems to be the deciding factor in determining whether the calcium concentration increases or decreases on shaking with calcium phosphate.

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- (1) M. Karshan - J.D.R. 15, 383 (1936)
 - (2) M. Karshan - ibid 18, 395 (1939)

PAPER NO. III

AN INVESTIGATION OF THE CHEMICAL COMPOSITION
OF SALIVA AND ITS POSSIBLE RELATIONSHIP
TO DENTAL CARIES

James J. Rae and Muriel Davies

1. The methods of analysis used in this study were:

(a) Phosphorus:— Kings Colorimetric Method⁽¹⁾.

In an attempt to divide the total phosphorus (T.P.) of saliva into its organic (O.P.) and inorganic (I.P.) fractions the usual method is to subtract from the phosphorus value obtained by digesting the sample with perchloric acid the phosphorus value on the trichloroacetic acid filtrate without digestion. When dealing with saliva considerable difficulty was encountered in trying to get trichloroacetic acid filtrates which would give clear solutions for use in either a colorimeter or a electrophotometer. Neutralizing the filtrate before adding the acid ammonium molybdate and amino-naphthol-sulphonic reagents; stronger trichloroacetic; the addition of electrolytes; the addition of alcohol; alcohol plus potassium acetate were all tried but none gave completely satisfactory and consistent results.

In order to overcome this difficulty the inorganic phosphate in the saliva was precipitated by the addition of magnesia mixture and the total phosphate of the filtrate was then determined. Tests were carried out which showed that the reagents added removed all of the inorganic phosphate from inorganic phosphate solutions and that the reagents did not adsorb organic phosphate from glycerophosphates or phenyl phosphates even in the presence of saliva.

(b) Calcium:- the usual KMnO_4 volumetric method.

An attempt to separate the calcium of saliva into an inorganic and organic component based on the differences in calcium between the trichloroacetic acid filtrate and a digested sample was unsuccessful since both these values were the same within experimental error. The precipitate obtained by adding trichloroacetic acid to saliva and the trichloroacetic acid filtrate itself without the addition of the usual ammonium oxalate reduced significant volumes of the KMnO_4 reagent. These blanks were too high to be disregarded. It was found however that digestion of the sample with perchloric acid reduced the blank to a reasonable level.

2. Karshan⁽²⁾ found that the amounts of calcium and phosphorus adsorbed by shaking with calcium phosphate differed in caries immune and caries susceptible. In our opinion barium sulphate makes a better adsorbent since it does not contain

either of the ions whose change in concentration is being measured. If the amounts adsorbed depend upon the form of calcium or phosphate present, protein precipitants such as ammonium sulphate and precipitation at the isoelectric point might give some indication as to the forms of these elements present in saliva. For comparative purposes an inorganic solution with a composition closely approximating that of saliva and a solution of Casec (Meads) were used.

A compilation of the results obtained on shaking saliva, Casec, and two inorganic salt solutions at different pH's with BaSO_4 , $\text{Ca}_3(\text{PO}_4)_2$, saturated ammonium sulphate and the effect of adjustment of saliva and Casec to their isoelectric points is shown in Table I.

TABLE I

	INORGANIC SOLUTION				CASEC				SALIVA			
	pH 4.21		pH 7.25		mg. %				mg. %			
Calcium Phosphate	I.P. mg. %	Ca mg. %	I.P. mg. %	Ca mg. %	T.P.	I.P.	O.P.	Ca	T.P.	I.P.	O.P.	Ca
Before	19.0	7.3	14.3	6.1	2.3	0.15	2.1	5-7	17.5			7.2
After	29.4	14.0	very high	5.6	300	190	-	8.4	53.0			3.4
Barium Sulphate												
Before	19.0	7.3	14.3	6.1	7.7	0.5	7.2	5.7	17.7	14.8	2.9	5.8
After	14.3	7.3	10.8	3.8	3.2	0.5	2.7	5.4	16.3	16.4		1.1
Sat. (NH ₄) ₂ SO ₄												
Before					7.7	0.5	7.2	5.7	17.7	18.4	-	5.8
After					1.4	1.0	0.3	5.7	12.8	14.0	-	3.6
Isoelec- tric Pt.												
Before					7.7	0.5	7.2	5.7	19.2	19.6	-	7.2
After					1.5	1.4	0.1	1.6	17.8	16.8	1.0	5.4

These results would lead one to make the following observations (1) Casec contains 94% organic phosphate. On shaking with Ca_3PO_4 both the Calcium and Phosphate concentrations increased showing that this solution seems to be unsaturated with respect to both calcium and phosphate. With BaSO_4 , the calcium remains unchanged and 60% of the total phosphorus is adsorbed, most of which seems to be organic phosphate. At the isoelectric point (pH 4.7) practically all of the organic phosphate and 72% of the calcium was precipitated.

When half saturated with $(\text{NH}_4)_2\text{SO}_4$ 82% of the total phosphorus and practically all of the organic phosphate was removed. This would seem to indicate that protein bound phosphate can be removed in this way.

(2) The inorganic solution at pH 4.21 was unsaturated with respect to both calcium and phosphate. At the higher pH however, there was a slight decrease in calcium even though the phosphate rose to two or three times its original value. The Calcium and phosphate components of Ca_2PO_4 seem to dissolve independently.

Shaking with BaSO_4 at pH 4.21 produced very little change but at pH 7.25 both the calcium and phosphate decreased probably due to adsorption.

(3) Saliva showed an increase of threefold in the phosphate and a decrease of 50% in the calcium on shaking with $\text{Ca}_3(\text{PO}_4)_2$. With BaSO_4 there was a slight change in phosphorus which may be due to adsorption of the organic phosphate and the calcium decreased to about 1/5 of its original value.

Half saturation with $(\text{NH}_4)_2\text{SO}_4$ produced no significant change in phosphate. Due to difficulties in determining the inorganic phosphate a loss of all of the organic phosphate could be overlooked. The decrease in calcium caused by this treatment need not be due to protein bound calcium since the inorganic solution showed a comparable decrease. The changes produced at the isoelectric point (pH 3.3) were not significant and this may be due to the mixture of proteins usually present in saliva.

3. In an attempt to ascertain the kinds of phosphoric esters present in saliva the rate of hydrolysis of the esters present was measured under various conditions. On standing at room temperature the organic phosphate in saliva was completely hydrolysed to inorganic phosphate in 72 hours. At 0° only 40% of the organic phosphate had hydrolysed in the same time, whereas if 50 p.p.m. of sodium fluorine is added no hydrolysis occurred even at room temperature in 72 hours. This fact was made use of in collecting salivas for analysis by adding to them small amounts of sodium fluoride

to prevent hydrolysis of the esters before analysis could be made.

The organic esters in saliva when hydrolysed by rabbit bone phosphate use at pH 8.0 showed 32% hydrolysis as 1 hour whereas sodium glycerophosphate under similar circumstances only hydrolysed 10%.

4. A series of salivas of varying susceptibility to caries were analysed with the results shown in Table II. These are arranged in the order of their Lacto bacillus acidophilus counts.

TABLE II

On the basis of this table there seems to be no correlation between the b.acidophilus count and the O.P. and O.P./T.P. values of saliva.

Case No.	Decayed Missing Filled	pH	Vol. of ppte.	T.P. mg. %	O.P. mg. %	I.P. mg. %	O.P. T.P.	Ca mg. %	Lacto Bacillus Acidophilus	
1	no rep.	7.71	2.2	12.7	1.60	11.1	0.13	9.0	0	Immune
2	no rep.	8.35	1.2	16.7	1.36	15.3	0.08	7.0	0	
3	18	7.60	1.4	10.8	0.77	10.0	0.07	6.0	0	
4	15	7.32	2.8	15.5	0.70	14.8	0.05	6.0	0	
5	15	7.28	2.0	14.0	0.99	13.0	0.07	4.9	0	
6	19	7.51	1.6	13.9	0.59	13.3	0.04	5.3	0	
7	7	7.70	1.6	10.4	0.68	9.7	0.07	5.5	100	
8	no rep.	7.72	1.4	9.3	1.54	7.8	0.15	5.6	250	
9	29	7.81	1.6	9.8	0.98	8.9	0.10	9.3	300	
10	20	7.25	2.0	14.0	1.13	12.9	0.08	7.6	450	
11	14	7.39	1.6	9.8	1.10	8.7	0.12	8.2	900	
12	15	7.40	1.2	12.2	0.77	11.4	0.06	5.0	1000	
13	10	7.64	2.4	15.0	1.75	13.2	0.12	5.7	2000	Average
14	11	7.13	2.0	12.1	0.58	11.5	0.05	5.8	2000	
15	9	7.4	3.0	11.6	0.93	10.7	0.08	4.3	3000	
16	13	7.61	1.6	10.4	0.85	9.6	0.09	6.3	9000	
17	8	7.41	1.4	12.0	0.88	11.1	0.07	5.8	10000	
18	9	7.00	4.6	16.9	1.08	15.8	0.06	6.7	12000	
19	21	7.10	2.2	11.5	0.64	10.9	0.06	7.3	12000	
20	12	7.25	2.2	16.7	0.73	16.0	0.04	7.3	12000	
21	no rep.	7.47	0.6	9.8	1.36	8.4	0.14	4.8	15000	
22	18	7.10	3.2	13.7	0.60	13.1	0.04	5.8	15000	Susceptible
23	10	6.90	6.0	17.0	0.83	16.2	0.05	5.4	30000	
24	24	7.45	2.0	13.7	0.95	12.7	0.07	5.1	36000	
25	13	7.18	1.6	10.9	0.74	10.2	0.07	5.9	36000	
26	19	7.11	1.2	11.2	0.80	10.4	0.07	6.1	45000	
27	23	7.42	1.8	10.1	0.59	9.5	0.06	5.2	60000	
28	17	7.39	1.4	11.7	0.55	11.1	0.05	5.1	60000	
29	18	7.19	1.8	11.6	0.52	11.1	0.04	5.8	75000	
30	10	7.18	3.8	17.2	0.92	16.3	0.05	6.1	75000	
31	21	7.05	2.2	18.7	1.30	17.4	0.07	6.9	120000	
32	no rep.	7.63	1.6	11.5	0.73	10.2	0.06	5.7	120000	
33	26	7.18	2.4	14.5	0.40	14.1	0.03	7.8	120000	
34	no rep.	7.15	2.0	13.8	1.21	12.6	0.09	5.0	300000	
35	15	7.00	2.0	11.2	0.94	10.3	0.08	4.4	360000	

SUMMARY AND CONCLUSIONS

1. The values for organic phosphate in salivas, as determined by precipitating the inorganic phosphate and doing a total phosphate on the filtrate varied from 0.40 to 1.60 mg.% with an average value for the samples analysed of 1.0 mg.%.

2. The amounts of calcium or phosphate adsorbed from saliva by shaking with calcium phosphate or barium sulphate or half saturating with ammonium sulphate are not a measure of the organic or inorganically bound calcium or phosphate in the solution since inorganic solutions show similar decreases. The changes observed seem to be more dependent on the pH of the solutions used.

3. The phosphoric esters in saliva do not hydrolyse enigmatically at the same rate as either glycerophosphate or phenyl phosphate.

4. There seems to be no relation between the O.P. O.P./T.P. values of saliva and the Lacto bacillus acidophilus count which was used as a measure of susceptibility to caries.

APPENDIX " C "

Subject: A comparison of the gas percentage delivery and percentage dial setting in anaesthetic gas machines.

Author: R.J.S. Tickle B.D.S., B.SC.(Dent.)

Project: DR 2

SUMMARY

Purpose: To determine the accuracy of gas machines to deliver accurately gas mixtures of the same percentage as that indicated by the regulating dials.

Scope: The method of procedure involved the use of a special nitrous oxide-oxygen gas analyser supplied by the Cambridge Instrument Co., New York. This instrument determined the percent by volume of O₂ in N₂O by means of thermal conductivity and was shown to be accurate to $\pm 0.5\%$. Three main types of anaesthetic gas machines were available for testing purposes and in all experiments these machines were set to function under what were considered normal conditions of operation during gas anaesthesia. In cases of doubt as to delivery, the manufacturer's instructions were followed as closely as practical. With each machine the N₂O-O₂ ratio of the mixture was varied and at each setting samples of gas were withdrawn for analysis.

Conclusions: Ample evidence is presented from the examination of 52 anaesthetic gas machines showing that many of the machines now in the hands of anaesthetists do not deliver the indicated dial percent settings of gas; some were seriously in error. Further, it was found that the volume of flow and pressure at which the gases are delivered is often at variance with the dial settings. It may be presumed that the use of gas machines delivering much less oxygen than that indicated on the dial settings, augments the hazards of gas anaesthesia.

APPENDIX " D "

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: Critical survey of the literature on dental caries.

Grantee: Dr. J. S. Bagnall

Project No. DR 7

Amount of Grant: \$225.

SUMMARY OF WORK

The Survey of Caries Literature is proceeding steadily and a great deal of work was accomplished this summer. I feel now that it is getting into the final stages and other than the current literature there is not much of the back literature to be covered. To date approximately 1600 articles have been reduced to precis notes and the indexing of these notes is well advanced. In addition about 1350 other articles have been surveyed but are not included in the definite bibliography.

Date: October 3, 1947.

APPENDIX " E "

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: Investigation of cements for methacrylate inlays.

Grantee: A.E.R. Westman

Project No. DR 12

Amount of Grant: \$5,000.
(including DR-5)

SUMMARY OF WORK

The regular progress reports from the Ontario Research Foundation have outlined the programme of research on this project and have described some preliminary work.

Briefly, it is proposed to use a formulation of synthetic resins as a cement for methyl methacrylate inlays. Thin films of these resins are transparent and when used as a cement should not cause a line of demarcation between an inlay and the tooth as the currently-used zinc phosphate cements do. Also, we believe that it will be more simple to formulate a suitable resin than to attempt to obtain a transparent cement from a complex inorganic reaction such as occurs in the case of the zinc phosphate cements. It is also proposed to seal the inlays in place by a "hot-melt" method--that is, by heating the resin applied to the tooth or the inlay, until it becomes soft and tacky enough to act as an adhesive.

It has been decided that a temperature of 135°F. should be the approximate working point of the resin. It is thought that a vital tooth can withstand this temperature for a few seconds without injury to the pulp. A number of formulations of commercially available resins have been prepared which meet this requirement.

At the present time we are considering suitable means of heating the resin. In this connection, several provisions have to be made with regard to technique and apparatus.

We are also giving consideration to other types of adhesives such as some known generally as room-temperature-setting adhesives.

October 3, 1947.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4703 - 11 March, 1947

Subject: Investigation of cements for methacrylate inlays.

Author: D. R. Christie

Project No.: DR 12

Scope

This report describes some requirements of and preliminary experiments on synthetic resins suitable as cements for methacrylate inlays when applied by a "hot-melt" technique. Some comments are also made on catalysts for the polymerization of acrylic cements.

Synthetic Resins as Methacrylate Inlay Cements

Synthetic resins offer the possibility of clear, transparent cements which would be ideal for use with methacrylate inlays. A "hot-melt" technique immediately suggests itself. In this process the inlay would be cemented in the cavity by applying heat to the cement causing it to soften and form a water-tight seal. The success of this procedure depends on (a) the tooth's ability to tolerate the temperature required to soften the resin and (b) the resin's ability to withstand, without softening, the temperature of the hottest foods or liquids which the patient may consume.

Requirements of a Hot-Melt Cement

We are awaiting more definite information on temperature tolerances of vital teeth but the information which we have indicates that a vital tooth should be able to withstand a temperature of 145°F. for a few seconds and that the average person is not likely to take food into his mouth which exceeds 135°F. It should be possible to formulate a resin which will soften at 145°F. but not at 135°F. As evidence of this we formulated a resin which softened at 122°F. but was unaffected by 113° F. This lower temperature of 122°F. was the objective since we thought previously that it would be unwise to expect a vital tooth to tolerate anything hotter.

Report No. 4703 (cont'd)

Formulation

The resins used were two grades of Piccolastics (styrene derivatives) and Staybelite Ester No. 2. Piccolastic B-75 is a hard, rather brittle resin softening at 75°C. (167°F.). Piccolastic A-50 is a tacky resin softening at 50°C. (122°F) and Staybelite Ester No. 2 is a tacky, balsamic resin which is soft at room temperature. The last two resins are suitable plasticizers for the first-mentioned.

Another formula for a higher-softening resin contains:

Piccolastic B-75 80%

Piccolastic A-50 10%

Staybelite Ester No.2 10%

This formulation has approximately the correct softening range for the "hot-melt" cement which we have proposed. A few small changes in its composition may be necessary.

Use of the Resin:

Chloroform and alcohol are commonly used solvents in dentistry and it is proposed to use a solution of a suitable resin in one of them to apply a thin film of the resin to the cavity walls. This procedure would be similar to the application of a cavity liner such as copal varnish. Some means would be used to heat the resin to its softening point and then the inlay would be inserted and held firmly in position until the resin cooled and hardened. The heat source could be warm water, air, an infra-red apparatus or the inlay itself. The best method will have to be determined in future experimental work.

Acrylic Cements

Some success has been attained in the use of methyl methacrylate monomer-polymer mixtures as direct restorations. It is thought that modifications of this technique may have possibilities as a cementing method especially if the material can be made to polymerize rapidly. We have been able to obtain several samples of polymerization catalysts of the peroxide type and we shall make a few tests with them. We have learned of other peroxy-compounds which are claimed to be more effective at lower temperatures but they are not available commercially.

Report No. 4703 (cont'd)

Future Work

(1) With the use of extracted teeth and methacrylate inlays for them, we shall study the use of a synthetic resin as a suitable cement when used in a hot-melt method.

(2) A brief study will be made of the use of materials for direct acrylic restorations with the view of adapting them for use as a cement for methacrylate inlays.

Author: D. A. Christie

Project No.: DS 12

This report is necessarily brief as considerably more attention is being given to project DS-5 in order to do as much work as possible before the college closes for the summer.

In the previous report we mentioned the use of a synthetic resin in a hot-melt technique as a means of cementing in methacrylate inlays. A method of cementing the cement by infra-red radiation was thought feasible and we have succeeded in obtaining some information on this subject. We have learned that a dry lamp, known as a "grain of wheat" lamp may serve our purpose and we have made inquiries about obtaining one. We expect to have shortly some extracted teeth and methacrylate inlays for them, to use in previous experiments.

Future Work

The program for this project is as follows:

- (1) To study the use of a synthetic resin as a cement when used in a hot-melt method with the aid of extracted teeth and methacrylate inlays for them.
- (2) To study the use of materials now used for direct acrylic restorations with the object of adapting them for use as a cement for methacrylate inlays.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION (DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4704 - 14 April, 1947

Subject: Investigation of cements for methacrylate inlays.
Author: D. R. Christie Research Fellow
Project No.: DR 12

This report is necessarily brief as considerably more attention is being given to project DR-5 in order to do as much work as possible before the college closes for the summer.

In the previous report we mentioned the use of a synthetic resin in a hot-melt technique as a means of cementing in methacrylate inlays. A method of heating the cement by infra-red radiation was thought feasible and we have endeavoured to obtain some information on this subject. We have learned that a tiny lamp, known as a "grain of wheat" lamp may serve our purpose and we have made enquiries about obtaining one. We expect to have shortly some extracted teeth and methacrylate inlays for them, to use in proposed experiments.

Future Work

The programme for this project is as follows:

- (1) To study the use of a synthetic resin as a cement when used in a hot-melt method with the aid of extracted teeth and methacrylate inlays for them.
- (2) To study the use of materials now used for direct acrylic restorations with the object of adapting them for use as a cement for methacrylate inlays.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Report No. 4705 - 14 May, 1947

Subject: Investigation of cements for methacrylate inlays.

Author: D. R. Christie, Research Fellow

Project No.: DR 12

This report is again necessarily brief because Project DR-5 has been receiving most of our attention. However, now that DR 5 is nearing completion, we expect to be able to give considerably more time to this project.

Acrylic inlays for extracted teeth are now being made and we hope to acquire very shortly some small infra-red lamps to be used in heating the synthetic resin cement according to plans previously described in these reports. In this connection, it has been suggested to us that an ordinary pen-flashlight of the type having a tiny bubble-tipped bulb might be a satisfactory heating apparatus for our purpose. This suggestion will be investigated.

APPENDIX "E"

ONTARIO RESEARCH FOUNDATION
(DIVISION OF CHEMICAL RESEARCH)

Dental Materials Research Fellowship

Note Regarding Project DR-12

16 June, 1947.

Author: D. R. Christie, Research Fellow

Project No.: DR 12

There have been no significant developments in the work on this project to warrant a progress report this month. It is expected that research on DR-12 will proceed more rapidly in the future now that the practical investigations on DR-5 have been completed.

APPENDIX " F "

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: The development of culture technique for certain fungus-like organisms found in periodontal disease.

Grantee: C. H. Best

Project No.: DR 16

Amount of Grant: \$1,100.

SUMMARY OF WORK

We are concerned in this study with the cultivation of the organism known as *Leptothrix falciformis* which is found in deep pockets in periodontal diseases. This organism appears to be a parent-cell process to which are attached falcate spores which when removed from the stem cannot be distinguished from the fusiform bacilli. Fusiform bacilli have always been included in the fusospirochetal group of organisms but the role they play in oral infections along with the spirochetes has never been fully understood. It is hoped that a culture technique can be developed so that other studies, such as morphology, pathogenicity and immunity, of the parent-cell process and the fusiform bacillus can be made.

We were unable to grow fusiform bacilli in our earlier work on any of the routine culture media, even when body fluids were introduced into the media. In later experiments we were successful in culturing fusiform bacilli on routine media when vegetable extracts were added to induce growth.

All of the fusiform bacilli strains grown could be divided into four types according to their morphological and cultural characteristics.

Smears of all cultures of fusiforms were carefully examined for the presence of the fungus-like organism found in periodontal disease; namely the *Leptothrix falciformis* organism described by Beust and Aisenberg. Not one smear revealed anything suggestive of a parent-cell process which we believe the *Leptothrix falciformis* is, for the fusiform bacillus.

Our observations of parent-cell processes in smears from deep pockets in periodontal disease lead us to believe that there are many strains of this fungus-like organism and this can be demonstrated by observation of parent-cells of different size and shape. Roughly, these organisms are made up of fusiform bacilli which fall into one or other of the four types mentioned earlier.

Efforts have been made to produce parent-cells from fusiform bacilli by alteration of nutritional requirements and environmental conditions without success. It is hoped that cultivation may be possible when greater stress is placed upon essential nutritional elements and nutrilites.

Through experiments on dogs, we were able to show that a change in the environment, by producing a pocket by surgical and mechanical means, brought about a change in the microbiological flora of the mouth. In gingival crevices of the normal dog's mouth we could only demonstrate a few members of the fusospirochetal group of organisms and these in small numbers. No parent-cell, burr-like processes could be seen.

After pockets had been produced and allowed to become infected, all the members of the fusospirochetal group could be demonstrated in smears and as well, the *Leptothrix falciformis* parent-cell processes. The infected smears were almost identical with those made from pockets in human beings from which a diagnosis of periodontal disease had been made.

The only difference that could be noted was that the falcate spores or fusiform bacilli, found attached to the parent-cells, varied in size and shape from those found in human cases.

Through the use of artificially produced pockets in the dog we are able to study the development of the organisms in the pocket. This study is being continued in order to see all the stages in the life cycle of the fusiform bacillus.

This work has been carried out entirely by Mr. D. C. O'Connell and Dr. W. J. Linghorne.

Date: October, 1947.

APPENDIX "G"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947.

Subject: An investigation of the effects of solutions used in operative dentistry on the vital pulps of teeth.

Grantee: R. F. Shaner

Project No. DR 17

Amount of Grant: \$500.

SUMMARY OF WORK

1. The literature from 1936 to the present was read and summarized.
2. Very courteous and useful communications were received from Manley, Orban, Grossman and Schour.
3. Using normal and pathological human teeth trial was made of various techniques of embedding and staining.
4. Experiments on animals were begun using rats and cats. Plans are made for using dogs and monkeys.
5. A possible relation between peripheral leak of some filling materials and the investigation in hand arose from repetition of an experiment by Grossman using glass tubes.
6. Dr. D. B. Scott of the Department of Physics offered to secure radioactive phosphorus to trace the penetration in the tooth of the orthophosphoric acid used in dental cements. Radioactive silver will also be used to trace silver nitrate placed within a cavity.

Date: October 2, 1947.

APPENDIX "H"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947.

Subject: Tissue toxicity and efficiency of local anaesthetics for topical application and nerve block in dentistry.

Project No. DR 19

Grantee: E. A. Sellers

Commencing July 2, 1947, Dr. H. S. Hamilton has undertaken a study of the properties of six local anaesthetics. These include two in common use, cocaine and procaine; three of the more recent anaesthetic agents, butyn, metycaine and intracaine; and naphthocaine, a substance which is of recent origin and is not yet available for general use.

The lethal dose or L.D.₅₀ for white mice as estimated by intraperitoneal injection, has been determined for each of these drugs. Some preliminary investigations on local tissue toxicity have also been carried out. Guinea pigs have been used as an experimental animal in this latter investigation.

A study of their comparative value as topical anaesthetic agents and their use in nerve block is in progress and it is also planned to investigate their tissue penetrability in various solutions, using the rabbit's cornea as the absorbing surface.

October 1947.

APPENDIX "I"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: An anatomical, histological and physiological study of the role of the condyle in mastication.

Project No. DR 11 (Report No. 2)

Grantee: R. J. Godfrey (Report prepared by Charles H. Moses)

Review of past studies

Our preliminary attempts to show macroscopic evidence of changes in the bony structures of the condyles and the fossae when function is altered on one side, did not meet with the anticipated results. Although previous workers attributed very evident bilateral differences in skull formations of humans (Tom Smith, J.A.D.A. 9, P.672, Aug. 1922) and animals when function was unilateral our experiments failed to produce any visible deformations. The posterior teeth of the rats (experimental) were removed at weaning time and the animals were sacrificed at maturity.

This phase of the experiment should not be confused with histological differences and differences in radiographic opacity, which will, of course, manifest themselves by various means. That bone alters when function alters is well known and much has been written about it. (Wolffe, Murk Jansen and others). It is also known that the fibres of the periodontal membrane organize to meet function. (H.K. Box)

Our experiments to date do not indicate sharply the alterations, if any that take place in the condyle. To be of value this should be very evidence macroscopically and easily interpreted microscopically. These preliminary experiments therefore indicate that another and more positive method must be undertaken. We have made several hundred sections through the condyles and study of these sections revealed very little information. It appeared to us through differences in staining that there was more synovial fluid on the functioning side. Another observation which we made appeared to be resorption of the trabeculae on the non-functioning side despite the fact that bone was building up all the time by growth. (Osteoclastic resorption).

Purpose of these Experiments

As a reminder, it should be repeated that these experiments were undertaken to prove experimentally that alterations do take place in the condyle because of the altered path which it is forced to take as a result of the altered articulation of the teeth. There is a school of thought which believes that no such alteration takes place. When artificial teeth are arranged and when the biting surfaces of the natural teeth are reconstructed to travel in new paths, alterations may be caused in the condyles and fossae if bone alters to meet new directions and degrees of force.

New Experiments

In order to prove that alterations take place, it is proposed to inject rats with Alizarine Red S. which dyes new growth of bone only. An attempt will be made to dye the bone at or just before the completion of bone formation. Thus a red ring will be formed outlining the condyle. Rats mature at 120 days and they will be injected at about 100 or 110 days of age. Then the teeth will be removed on one side, about 30 days later and the rats will be sacrificed at 30, 60 and 90 days. It is expected that there should be breaks in the ring where there is resorption and additions to bone outside the line where there is deposition.

Our preliminary attempts with Alizarine Red S. during the summer to ascertain the definition of the lines did not sharply differentiate these lines when the rats were injected at weekly intervals. Dr. Drake at the Sick Children's Hospital, Toronto, suggested that we use on our new animals the same dye as used by Schour of the University of Illinois. We have already obtained the dye after considerable delay. We have now obtained eight rats born Sept. 1, 1947, and will inject them Dec. 10, 1947. Perhaps we will sacrifice one or two previous to Dec. 10th or inject one to see the effect of the dye.

The Axis of Opening Movement of the Mouth

Perhaps the most important achievement to date in our investigation was the hinge axis of the opening movement of the condyle. Nearly all anatomists are agreed that the axis center is in the vicinity of the mandibular foramen. Gray is the exception, for he states that it is in the condyle. It does not appear that Gray made an accurate study of this. McCollum and the gnathological society of California have proclaimed to the world that there is a hinge axis in the condyle and that it is locatable and may be permanently marked

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by a tattoo mark on the skin. They have devised a gnathoscope and a gnathograph, and by means of the latter this axis is located. A visit to Dr. E.R. Granger, Mt. Vernon, N.Y., to observe this procedure in operation convinced us that the hinge axis in all probability is in the condyle.

In order to prove that the condyle on mouth opening need not move forward, we have done one experiment to date. (Numerous other experiments are projected). We had a patient open his mouth at three different levels by means of a central bearing pin within the mouth. With this pin he described a gothic arch on a table. The apex of this arch is near centric position, (at which position both condyles are in their most retruded, unstrained position). With the pin at the apex at each of the three levels a radiograph of the condyle was taken. The condyle did not move forward perceptibly. This experiment, we believe, is too inaccurate to use in locating the axis because of the instability of the dentures in an edentulous patient, and of the inaccuracy of the procedure placing the head in the same position each time. We merely attempted to show that the condyles on mouth opening do not have to move forward.

This fact is of great significance because if the axis is in the vicinity of the mandibular foramina and we construct complete artificial dentures on an instrument with the hinge in that position, every calculated movement will be wrong if the axis is wrong. If we use an adjustable articulator it must locate the hinge very accurately. We will conduct more accurate experiments when the new cephalometer is installed at the Faculty of Dentistry.

Bennett Movement

The Bennett movement is the lateral shift of the rotating condyle while the working condyle is travelling in the mandibular fossa. The gnathographs and gnathoscopes reveal that the rotating condyle may not only move laterally as it rotates, but may also move up or down. Furthermore it has an exact path which is constant. Repeated recordings taken at intervals of several months or years will give the same reading every time. This lateral shift must influence the articulation of the teeth and if not taken into account could cause damage to the ridges in edentulous cases and periodontal tissue in dentulous cases. What causes the Bennett movement? We believe it to be performed by the action of the lateral pterygoid muscles or portions of these muscles.

The Lateral Pterygoid Muscle

The lateral pterygoid muscle has two heads, an upper head and a lower head. These heads are almost at right angles to each other. From their appearance it might be presumed that they are two separate muscles. Nature does not so sharply differentiate structure unless the function is sharply differentiated. Pantographic tracings on the gnathograph indicate that the lateral shift is recorded either at the beginning of the movement or after movement has been initiated. Perhaps one of the heads comes into play during one phase of movement and the other during another phase.

Proposed Experiments

A cadaver will be dissected leaving only the ligaments and the lateral pterygoid muscles. Wire threads will be drawn through the muscles to their origin and through the cranium. When the muscles are defleshed the threads will simulate the muscles and will be activated by pulling them through perforations of the cranium. A study will be made of the action of both heads of these muscles.

Summary

1. No gross changes are indicated by unequal growth of the functioning and non-functioning sides of the skulls of the animals.
2. Histological evidence was inconclusive because the experiments were conducted while the rats continued to mature.
3. Experiments will be undertaken when function will be altered and a sharp line will be formed at conclusion of growth with Alizarine Red S.
4. The axis of opening movement is in the condyle despite the fact that the vast majority of anatomists place it in the vicinity of the mandibular foramen.
5. Our preliminary experiment bears out the same fact. Additional work will be done on this problem.
6. The Bennett movement is a definite movement of the mandible and is constant.
7. The Bennett movement may be caused by one of the heads of the lateral pterygoid muscle coming into play during the movement.
8. Experiments are being conducted to determine the different actions of the two heads of the pterygoid muscle.

October 4, 1947.

SUPPLEMENT TO APPENDIX "I"

Dr. R. G. Ellis,
Chairman,
Associate Committee on Dental Research.

National Research Council

Project DR 11

Dear Doctor Ellis:

Herewith is a statement of expenditures re a visit by myself and Dr. Moses to Dr. E. R. Granger, Mount Vernon, New York. It was felt that discussions with Dr. Granger who is familiar with the McCallum recording devices and Gnathoscope and who has made an intensive study of this subject would be a benefit in the investigations under DR 11 and this is amply borne out by what we observed and many controversial points have been made clear.

Study of the temporo-mandibular joint from the standard texts in anatomy does not give the true dynamic picture of the complex movements. The peculiar movements and shifts of the condyle are not depicted since a cadaver is not the ideal medium for a complete study of mandibular movements. Much additional information may be obtained by utilizing pantographic reproductions of these complex movements on a recording device and these movements may actually be reproduced and standardized. In this manner a clear picture may be obtained of the various axes of rotation and the accompanying paths of condylar movements.

Of utmost importance, and a factor which has been underemphasized, is the exact location of the hinge axis of opening and closing the mouth. Nearly all anatomists agree that the hinge is located in the vicinity of the mandibular foramen. It appears however from our studies that the condyle moves forward when the mouth is opened and therefore the axis may be located elsewhere. McCallum proves conclusively that the mouth may be opened a considerable distance without the condyles moving forward on the eminentia articularis. This fact has been demonstrated to us by his instruments by means of which he positively locates the hinge axis of the opening movement of the condyles. This point is of the utmost importance to Dentistry and Medicine.

Prosthodontists will find the accurate placing of the hinge axis of opening movement of the utmost importance because all eccentric movements may be traced from this starting point. On the other hand, the wrong location may result in placing the teeth of artificial appliances in improper relationship with attendant deleterious results.

Periodontists, also may utilize this information in evaluating conditions where teeth are in traumatogenic occlusion.

In addition, Orthodontists may also use this information in comparative studies of the relationship of the axis centres to growth and movements and as a final check on completed cases where teeth have been moved into new positions.

Studies with an instrument of this nature may be made of the actual movements of the condyle along the condyle path rather than accepting the "equivalent" movements or relationships which we have been led to believe were correct and which "equivalent" only, are incorporated on the majority of articulators. This belief, we now know is fallacious.

The condylar path, in the light of recent observations, may have waves of movement which should be reproduced rather than a straight line joining the beginning and the conclusion of movement. These wavy paths may have been formed through peculiar chewing habits caused by numerous factors in each individual.

The peculiarities of the Bennett movement, which formerly appeared to be so complex, is now found to be recordable and very essential in the studies of condylar movements.

The centres of rotation on the horizontal plane, the transverse vertical plane and the sagittal plane must be given further and intense study and it will be possible to record these centres. In the past these motions were studied on two planes only and were in consequence very inaccurate. It may be safely assumed, that up to the present, mandibular movements have been most inaccurately observed and recorded. It is now possible to record and to study these movements most accurately by means of the recording devices and an articulator that reproduces all the movements of the mandible.

As a corollary to these studies of condylar movement, the placement of artificial teeth may now be investigated more thoroughly and accurately. Another important study is that of tooth form. In the light of this new found knowledge every marginal ridge, every incline plane, every transverse ridge and every cusp has a positive meaning and an exact contour and position.

We respectfully submit, therefore, that further studies are warranted which it is believed will disclose knowledge and important information on condylar movements.

R. J. Godfrey,

11 June, 1947.

APPENDIX "J"

INTERIM REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

SUBJECT: A study of micro-organisms found in periodontal pockets and dental caries, as revealed by the electron microscope.

AUTHOR: H. K. Box, D.D.S., Ph.D.

PROJECT NO.: DR 3

SCOPE: In the majority of sections of human periodontal pockets, as shown in illustrations in text-books and current dental magazine articles, the cellular debris and contained organisms present in life are missing. This soft material has been lost in the making of the microscopic preparations. Obviously, these washed-out sections do not disclose the true nature of the periodontal pocket, and, in particular, certain relationships of unique forms of pocket organisms to changes occurring in the epithelial wall of the pocket.

In 1944, and 1945, I reported the finding, in sections of human periodontal pockets containing the cellular debris at the base and along the hard and soft tissue walls of the pocket, of complex organisms that resemble certain forms described by Beust, the Deans and other workers. Their close proximity to necrotic changes in the adjacent pocket epithelium suggested a causal relationship.

The parent organism described by Beust, and to which he gave the name *Leptothrix falci-formis*, was classified by him with the algae-like fungi. The conidia, or asexual spores, of this organism were regarded by Beust as identical with fusiform bacilli. It is interesting to note that, according to him, these conidia (fusiform bacilli) are provided with peritrichate flagella.

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The finding of this organism adjacent to regions of necrotic epithelium, and their apparent free bacillary forms in the necrotic epithelial cells, seems, in a measure, to confirm Beust's belief that these organisms are pathogenic. It was thought that valuable information could be gained, through the use of the electron microscope, as to phases in the life-cycle of this higher bacterium, through an examination of material obtained from deep periodontal pockets. The question of the presence of a virus in periodontal pockets was also kept in mind.

In this study, to date, 96 photographs have been made with the electron microscope; 24 from material taken from periodontal pockets in selected cases of Necrotic Periodontitis, and 72 from carious dentine in freshly extracted teeth. Further examination of pockets is still being carried out, noting carefully the type of periodontal disease from which the material is obtained. A full report on the findings, including those of carious dentine, will be made at a later date.

October, 1947.

APPENDIX "K"

INTERIM REPORT

to

ASSOCIATE COMMITTEE ON DENTAL RESEARCH

Subject: Experimental Production of Dental Caries.

Authors: H. K. Box, D.D.S., Ph.D. and R.A. Hugill, D.D.S.

Project
No.: DR 18

Purpose: Fundamentally, the new and old theories (Miller, Williams, Hawkins, Mellanby, Bodecker) agree that there are two active phases in the development of dental caries namely the acid phase and enzyme phase. Oral bacteria are thought to produce both the acidity and the enzymes. Briefly one modern hypothesis is that acid activity initially is responsible for decalcification, followed by enzyme proteolysis which digests the organic matrix of the tooth structure involved. The bacteria follow up the above advancing processes.

Employing these basic theories, it is being attempted to artificially produce caries, by first inciting artificial decalcification by various acids, then reproduce proteolytic activity by enzymes, and introduce finally, bacteria to complete an artificial picture of true dental caries. The acids, enzymes and bacteria to be used are of non-oral origin.

- Scope:
1. Intensive survey of literature pertaining to the work on the caries problem.
 2. Acid-forming bacteria were found to be present in whole grain flour, producing fermentation of the carbohydrate content of the flour, and a resultant increase in acidity as the process continued.
 3. Acid-forming bacteria obtained from whole grain flour incubated in sterile 20% solution of sugars, (maltose, sucrose, glucose) and starch, increased the acidity from pH. 7.0 to pH. 4.0 in 48 hours. Bacterial smears of the solutions demonstrated the presence of cocci and fungus organisms. Tests for acids produced by the organisms showed the presence of lactic acid in all solutions and a trace of tartaric acid in the maltose solutions. Acids tested for:- Lactic, Malic, Succinic, Tartaric, Pyruvic, Formic, Phosphoric, Citric, Butyric.

4. 1% solutions brought to pH. 4 with 1% NaOH of Lactic, Citric, Tartaric, Succinic, Pyruvic, Butyric, Acetic, Phosphoric, Malic, Propionic, Formic acids, were used in attempts to show enamel decalcification of freshly extracted teeth. From macroscopic observation considerable variance in decalcification was produced by the various acids at the same pH. as follows:-

- (a) Lactic acid decalcification +++
- (b) Acetic, Citric, Tartaric, Succinic, Malic, Propionic acid decalcification + +
- (c) Butyric, Formic, Phosphoric, Pyruvic acid decalcification +

Microscopic observations have not as yet been obtained from ground sections which are being prepared.

5. Preliminary experiments with enzymes, pepsin and papain (5% solutions) are being used to determine their effects on freshly extracted teeth. Results from effects of neutralized (to pH 7.0) enzyme solutions, and from enzyme solutions in water (pH.4) on extracted teeth have not been determined as yet, but are in progress. Thymol was added to enzyme solutions to eliminate bacterial action.

Conclusion: At this date, no definite conclusions can be drawn from the above experimental work.

October, 1947.

APPENDIX "L"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: A study of methods of fluorine analysis to be applied to extracted teeth from people living in different parts of Ontario.

Grantee: M. Doreen Smith

Project No. DR 13 Amount of Grant: \$1,050.

SUMMARY OF WORK

The work of Bibby and Van Kestern (Journal of Dental Research, Aug. 1940) which found fluorine concentrations of less than 1.0 p.p.m. to limit acid production from carbohydrates by oral bacteria was duplicated. The organism used was a strain of *L.acidophilus* obtained from the Faculty of Dentistry, grown on Jay's broth(ph.5.0). It was found that with increasing concentrations of fluorine from 0 to 60 p.p.m. there was an apparent straight line relationship between the acid produced and the fluorine added. Since the decrease, believed due to bacterial enzyme inhibition by fluorine, does follow a linear course in standardized experiments it does appear that a microbiological assay technique for the quantitative estimation of fluorine has been established.

The effect of 0.001 M. concentrations of phosphate chloride, sulphate and ferrous ions was investigated. No effect on total bacterial acid production was noted. However, due to a precipitate reaction no definite conclusions have been reached on the effect of sulphate or ferrous ions.

During the summer months this strain of *L.acidophilus* was lost and at present we are in search of a pure strain of the same type.

Since *L. casei* is currently being used in microbiological assay this culture was obtained and tested for fluoride effect. No effect was noted in concentrations of 0-5 p.p.m.

Chemical methods for the measurement of fluorine are also being set up.

October 7, 1947.

APPENDIX "M"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947.

Subject: Fluorine analysis of water and food samples from different areas in Ontario collected and studied in relation to incidence of dental caries.

Grantee: M. Doreen Smith

Project No. DR 14 Amount of Grant: \$1,125.

SUMMARY OF WORK

Correspondence has been carried on with Dr. R. H. Ferguson, Public Health Dentist, Kitchener and Dr. H. B. Kenner, M.O.H., Stratford re the collection of samples of water, milk and potatoes from these centres in Ontario.

In order that the data accumulated during the survey will have all possible significance, a statistician has been consulted to check on our plan with respect to number of samples to analyse, number of determinations to carry out and times to collect. This plan is now being put into action.

Preliminary analyses are being carried out on Toronto milk etc. to standardize the technique and methods for the analysis of the fluorine. The microbiological method being developed in this department and also the chemical method are being tried to determine which will be most satisfactory to apply to the various materials for routine analysis.

October 7, 1947.

APPENDIX "N"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947.

Subject: To study the effects of altitude acceleration and deceleration on oral tissues.

Grantee: E. M. Wansbrough

Project No. DR 6

SUMMARY OF WORK

Research on the above project is being carried on during spare time at RCAF Station, Eglington.

Due, however, to a deficiency of available personnel for study, it is impossible at this time, to present any conclusive observations.

14 October, 1947.

APPENDIX "N"

R.C.A.F. STATION, TORONTO, ONTARIO.

NO. 5 DENTAL CLINIC

PROJECT REPORT

DATE: 8 October, 1947.

SUBJECT: A Bibliography of Aviation Dentistry

AUTHORS: ROYAL CANADIAN DENTAL CORPS

PURPOSE: To compile an up-to-date authors index on publications directly concerning the subject of aviation dentistry.

CONCLUSION: A bibliography of aviation dentistry has been prepared. It is hoped that this index will be of value to individuals interested in or investigating problems in aviation dentistry.

REPORT BY: E. C. PURDY, Major, R.C.D.C.

A BIBLIOGRAPHY OF AVIATION DENTISTRY

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APPENDIX "O"

REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947.

Subject: An investigation of the effects of certain chemicals on materials in appliances used in prosthetic dentistry.

Grantees: Drs. O. J. Walker and H. R. MacLean

Project No. DR 9

Amount of Grant: \$1,000.

SUMMARY OF WORK

Dental alloys that are being used at present in this research are those that are sold under the trade names of Denchrome, Durallium, Vitallium and Triconium. These are alloys containing chromium, vanadium, cobalt and nickel. The chromium and vanadium content have been determined and analyses for cobalt and nickel are in progress.

A start has been made on the study of the corrosive effect on these alloys of Stera-Kleen, Polident and Hygeol. Test pieces of the alloys are suspended in saturated solutions of the first two liquids or in solutions of the third of different concentration. Flasks containing the solutions are placed in a thermostat at a set temperature and shaken from time to time. The test pieces are 1 cm. square and corrosion is determined by loss in weight.

In the preliminary experiments, the time of exposure has been limited to 48 hours at temperatures in the neighborhood of 50°C. The results so far obtained indicate that corrosion resistance of the alloys to Stera-Kleen and Polident is quite good. Results for experiments covering several months exposure are not yet available.

The experimental work is being carried out by Miss D.E.R. Coggles, B.Sc.

October 17, 1947.

A P P E N D I X " P "

TROPICALIZATION OF DENTAL SUPPLIES AND EQUIPMENT

by

Dwight S. Coons, D.D.S., F.I.C.D.

The report presented herewith, by permission of the Department of National Defence, is based on the data gathered by the author in India, Ceylon and North Africa. The survey was undertaken on behalf of the R.C.D.C. in preparation for possible use in tropical climates in the war against Japan. As Japan capitulated before Canadian Forces were called upon to take the field, the alteration of R.C.D.C. equipment and supplies was not completed. The findings are condensed in this report for reference and record purpose.

It should be stated at the outset, that there was very little information available as to the exact behaviour of certain items of dental supplies and equipment, under tropical conditions, although there were many reports from various sources as to the unsuitability of some items, which were satisfactory in more temperate climates. The observations of civilian dentists in tropical areas apparently did not receive the full attention of dental supply houses, most of which are situated in temperate climates, such as Britain and the U.S.A. As a result, the practitioners were forced to accept the supplies as shipped and little was done to adapt, or change items for hot climates, except some concessions in the methods of packaging for shipment. Even the latter attempt to improve matters was inadequate and gave little, if any, thought to storage in smaller units on arrival. The dental officers with the Armed Forces in these areas were handicapped more than civilians because working quarters, in most cases, were situated in barracks, while in forward areas a tent or a hut was the general rule. Thus a partial control of temperatures, humidity, and the exclusion of insects was a problem, which not only had an adverse effect on dental supplies, but, in many instances, limited the amount and type of dental treatment which could be given.

In general, the information sought and the recommendations arising from this review have, as an objective, the provision of dental treatment for Canadian personnel on as comprehensive a scale and to the standard now obtainable in Canada. In consequence, consideration is given to working conditions for personnel in tropical areas, and the necessary administrative requirements as well as the effects of climate on dental disease, stores, equipment and supply problems. While the area covered by these observations was confined to India, Ceylon and North Africa, the survey should be equally applicable to other tropical areas. Specific subjects are covered under their respective headings.

Dental Treatment

1. Comprehensive dentistry can and should be provided in all forward areas. Not only is it important from the standpoint of maintaining dental and hence physical fitness as an adjunct to keeping down the number of ineffectives due to dental causes, but it is desirable from a morale standpoint. The latter point is worthy of consideration and is of more importance than in other theatres of war such as the U.K. and Canada. This item was emphasized many times to the writer by C.O.'s of units and officer and airmen patients.
2. The term "forward area" insofar as army is concerned is taken to mean an infantry brigade area from which dental detachments may be allotted to battalions or batteries as circumstances dictate. The Dental Company Headquarters, of course, should be at divisional headquarters, but it is felt that more or less static units can be stationed at brigade. Due, however, to the nature of the terrain, battalions, brigades and divisions are dispersed over a much wider area than in Europe and decentralization of dental detachments is necessary mainly because of the difficulty of communication. The last statement includes the transport of patients and involves time lost by patients in travelling from one area to another. Reference is made elsewhere to the high rate of sickness which affects the strength of units, and service rendered as far forward as possible is most desirable. Insofar as the rear area units are concerned, the proper service can be organized by the Company Commanders to suit conditions.
3. The term "forward area" insofar as R.C.A.F. is concerned is defined as a wing headquarters. This headquarters is usually somewhat further to the rear than a brigade headquarters in army, consequently, lines of communication do not present as many difficulties. The latter are simplified still more for heavy bomber and transport groups, because they are usually located further to rear than tactical air force groups. In addition, transport by air is oftentimes feasible and the supply problem is not as serious or difficult as for army. All personnel of each squadron in a wing can be provided with dental treatment at this point even though the squadrons are dispersed to some extent. In most cases, the dispersal does not cover a very wide area and is not sufficient to prevent patients coming to a more or less static and central dental clinic. The appropriate service for group headquarters controlling a number of wings is a matter of arrangement to suit conditions and static dental clinic accommodation can be set up in more permanent buildings.
4. There appears to be no reason why all phases of prosthetic and operative dentistry including the first phases of jaw surgery, cannot be provided to personnel of the army and air forces on the spot. It is true that dental officers would of

necessity be working under adverse conditions, and to that extent the amount of work per day or month would be considerably lower than in temperate climates. It is the observation of the writer that the initiative of dental officers tends to overcome many of the difficulties encountered and this should be aided by the changes contemplated and recommended for supplies and kits.

5. The present dental kits A, B, C, and D can be transported to the forward areas designated, i.e. brigades and wing headquarters. From that point, particularly in a war of movement there will be a distinct advantage in having smaller man-borne field kits based on the present items of supply as an adjunct to the trunks now on issue. This is already under consideration by the Interdepartmental Committee. It is recommended, however, that these new kits be issued together with the dental trunks to be used as circumstances arise. An additional advantage of such kits would be for use in possible amphibious operations. It would appear that man-borne kits should be designed for the relief of pain, extractions and the repair of dentures.

6. The British Army and R.A.F. dental services do not provide all phases of dental treatment to the same extent as the U.S. and Canadian Corps. For one thing, the technical personnel are not available nor is the equipment supplied of the same standard. Very little has been done to date in the way of improving dental equipment and supplies for use in tropical areas although some consideration is now being given to the subject. The present standard of dental treatment for Canadian personnel should be maintained in tropical areas. While there is a shortage of C.D.C. officers, it is advisable to approximate the ratio of 1:500 as closely as possible in order to give effect to the aforementioned policy on treatment. It is apparent that a considerable backlog of dental treatment exists for the armed services, - other than Canadian - in India and the above recommendation is submitted with a view to keeping the number of non-effectives from dental causes as low as possible.

7. It is highly desirable that only the younger group of C.D.C. personnel be chosen for posting to tropical areas.

General Observations on Dental Diseases - India, Ceylon and Burma.

1. Inquiries were made at U.S. and British dental centres as to the availability of statistics on the number of non-effectives from dental causes only. Neither service have kept such statistics, as records are listed by the Medical Service usually in hospitals and the incidence of dental disease is not recorded except in the cases of jaw injuries.

2. In conversations with the Dental Officers of the C.D.C., U.S. Army, British Army and the R.A.F., the consensus of opinion is that the incidence of Vincents Infection is markedly lower in China, India, Ceylon and Burma than in the United Kingdom or America. There seems to be no unanimity of opinion as to the cause of this condition. Some of the theories advanced attribute the lack of this disease to the plentiful sunshine and the availability of citrus fruits. It is to be noted that the clothing worn by troops in tropical countries consists of an open-necked shirt together with shorts for daytime wear thus exposing much of the body to the direct and indirect rays of the sun. In so far as it could be ascertained no research on the subject of Vincents Infection has been undertaken in this area.

3. While there is a marked absence of Vincents Infection, as reported in the preceding paragraph, it has been observed, however, that a very heavy formation of calculus appears on all teeth. This is accompanied by a form of black stain which sometimes necessitates the use of a round bur to remove. There is, of course, pocket formation together with gingivitis with consequent loss of tissue and loosening of the teeth. Removal of the calculus usually leaves considerable destruction of the gingival tissues. Very little has been done to correct the occlusion. General debility is evident particularly following malaria and dengue fever.

4. Recurrent caries appears to be lower than in Canada. This is a snap observation of C.D.C. Dental Officers serving R.C.A.F. personnel. In other words, it would appear that the rate of decay is retarded after personnel have served in this theatre for periods of 8 - 12 months.

5. Most Dental Officers agree that the occurrences of dry sockets after extractions are rare in the Indian theatre. Again no logical reason could be given for this and there are no statistics available for comparison with North American experience.

6. It is stated by both Medical and Dental Officers that the healing of bone in the India, China, Burma area takes from three to four weeks longer than is necessary in the United Kingdom or Canada. This applies to jaw fractures as well as the long and other bones of the body. It is most general during the summer months and is more applicable to individuals who have been serving in the area over a considerable number of months, probably a year at the least. Again no adequate explanation could be obtained although the Dean of Calcutta Dental College, Dr. Ahmed, attributes the cause to a general lowering of resistance due to inadequate diet and the aftermath of fevers such as malaria.

7. It would appear that syncope or fainting is of much more

common occurrence in tropical areas during the administration of local anaesthetics. Causes are evidently due to heat, lowered vitality, latent fevers, etc. In some places, it is now routine to give anti-malarial treatment before major operations under local anaesthetics are attempted, e.g. the extractions of a comparatively large number of teeth using block injections.

Administration of Dental Treatment Policies

1. A review of British Army and R.A.F. methods of allotting dental personnel shows that the system in general is based on medical units and it was considered that this is not entirely satisfactory from a practical standpoint of bringing dental treatment to the patients, and thus avoiding evacuation. To a lesser extent, U.S. Army methods are similar.
2. Due to the wider dispersal of units in this area, it would be more practical to disperse dental personnel as close to a large concentration of troops as possible, without particular reference to medical formations. This is in line with C.D.C. policy and does not rule out the provision of dental treatment at hospital units.
3. The system in use by the C.D.C. of allotting dental companies to specific formations should definitely be retained in the Eastern theatres of war. As a rule, the distances are great and transportation is comparatively poor even by road. The companies system permits the allotment of dental detachments where and when required to the extent that any and all units may be provided with dental treatment without tying up an excessive number of dental officers to a given unit.
4. An A.D.D.S. should be appointed to the appropriate H.Q., both army and air force. This officer to be responsible to the senior Canadian G.O.C., or A.O.C., as applicable and to D.G.D.S., N.D.H.Q. for technical dental administration.
5. Dental companies should be attached to an army division or an air force group. In the case of air force groups one dental company would probably be sufficient for two or more groups. This is preferable to an empirical geographical sphere of responsibility because it accomplishes the same purpose and has advantages of remaining mobile, in so far as accompanying the units to be served is concerned.
6. Due to the high sickness rate, it is recommended that an increase of approximately 20% of personnel be provided as compared with the field or base dental company establishments now authorized for the U.K. and Europe.
7. A central depot of dental stores located at the main port of the area concerned should be set up for both army and air

force on the same basis as is now in force for the European theatre. Definite problems in connection with shipment and storage of dental supplies is covered by another report. Both British and U.S. dental departments have experienced considerable difficulty from various causes in connection with the issue of dental supplies because of the lack of trained dental quartermasters. Issues are the responsibility of medical personnel with little knowledge of dental requirements and the C.D.C. system of providing trained Q.M.'s is much superior from a practical standpoint.

8. It is also strongly recommended that the tour of duty for dental officers in tropical countries be limited to one year exclusive of travelling time. The confining nature of dental practice demanding as it does a high degree of precision and skill requires good health under the best possible working conditions. This requisite is perhaps more important than the majority of other lines of communication, appointments or trades and the foregoing recommendation is accordingly felt to be justified.

Dental Equipment - Dental Trunks

1. From a construction point of view, dental trunks are standing up well in tropical areas. Aside from rust, there has been some minor damage to locks and hardware in transit, but no more than the usual wear and tear.
2. Considerable care is required to prevent the rusting of hardware, particularly in the locks. Frequent oiling is a satisfactory preventive.
3. There have been no complaints that insects have attacked the body or interior woodwork of the trunks, and it is thought this is due to the fact that all exposed parts have been painted. In this connection, however, it is to be noted that observations were confined to places where conditions are not so severe as might be expected in forward areas.
4. It has been observed that the condensation of moisture is common inside the trunks both during sea voyages in the holds of ships and when not in use in places where humidity is high. Condensation on the outside of the trunks is an everyday occurrence during the monsoon period.
5. Due to moisture some swelling and warping of the interior woodwork was noticeable, but it was not sufficient to render the drawers useless because C.D.C. officers took the precaution of applying waterproof paint to all exposed parts before much damage had occurred.
6. The consensus of opinion is that unprotected plywood is

not entirely suitable in the forward areas where damp humid conditions prevail most of the year. However, no difficulties have been noted in so far as dental trunks are concerned.

7. The only precautions necessary against excessive condensation of moisture and damage from insects is to insure that the painting of all exposed parts is kept in good condition. All interior woodwork should be painted on all surfaces. The rusting of hardware can be prevented by frequent oiling although rust-proofing of the metal would be of advantage.

Mobile Dental Clinics

Observations on Operating Conditions

1. The vehicle is considered suitable in every way for the purpose of which it was designed, except for the observations listed below. This is applicable only to tropical areas.

2. In the desert areas of North Africa the average mean temperature in the summer ranges from 90° to 120° Fahrenheit. Winter temperatures are not much lower. Humidity is low. For areas in India and Burma, the temperature range is about the same, but the humidity is very high.

3. In the above desert areas where no shade is available, the heat absorption on the metal body produces an average day temperature of 120° Fahrenheit inside the vehicle. This occurs even though the Coleman stove was not being used. When the Coleman stove was in use for sterilizing, the temperature rose approximately 50°F. The use of mentholated spirits was resorted to with very little rise in temperature. It was stated that difficulty was encountered in obtaining mentholated spirits in sufficient quantities, however, since a large stock was not carried.

4. A canopy of canvas covering the area of the roof only, permitting a draught to pass between the roof and the canvas, lowered the temperature from 50° to 100°F. A further lowering of the temperature can be effected by extending the canvas beyond the roof on both sides, but this was not considered feasible because the natural light would be cut off.

5. Another cause for excessive heat in the clinic is the lack of escape ventilators in the roof. While there is through circulation, the upper third does not benefit greatly and the heads of the patient and operator are in this area during operating periods.

6. Recommendations - The present vehicle can be modified to make use of mobile dental clinics in tropical areas, and the following changes are recommended. In this connection it is

thought that Unit workshops can make most of the modifications.

(a) A camouflaged, removeable canvas covering, treated for rot prevention can be supplied as a canopy for the roof as a protection against the direct rays of the sun in tropical areas. When in place it should be about 1 foot above the roof and extended about 6 inches on either side of both side walls of the vehicle.

(b) Installation of a fan near the centre of the cab end of the vehicle and placed as close to the roof as possible.

(c) Provision of oblong water-proof slide windows of perspex on both sides of the vehicle, this window to be situated one-half on the roof and one-half on the side wall. The advantages of this window would be two-fold - firstly, it permits circulation and the escape of warm air, and secondly, it provides additional light. A blind for the inside of the window would be required.

(d) As an alternative to the construction of windows, for ventilating purposes only, it is suggested that two water-proof ventilator shafts fitted with wind-propelled fans would be feasible, providing they had no effect on the clearance height of the vehicle.

Additions to Dental Kits for Tropical Service

Because of unusual operating conditions, it is suggested that the following be added to Dental Kits for use in tropical areas:-

(a) One or possibly two small electric fans, preferably those with rubber blades. These will serve two purposes. First, to create a current of air for both patient and operator and thus give some relief from heat and excessive perspiration so that operating conditions may be improved. Second, and more important, to keep the myriads of insects from gathering around personnel and instruments, especially when using artificial light. Some method to keep insects away is absolutely necessary from the standpoint of asepsis and the use of fans is a reasonably effective method, especially when used in conjunction with mosquito nets and screens.

If dental clinic accommodation of static nature is used it will be found that large ceiling fans are already installed or can be provided in most living quarters in built-up areas and dental operating rooms are selected accordingly in common with all office space, dining rooms and sleeping quarters, etc. However, small fans in the kits would be required in forward areas and can also be used to advantage as supplements to this type of accommodation.

The question of electric power provides a problem if the fans are not run from the generator supplied with mobile clinics. The power available in India varies from 220-240 volts according to the surge of current and the load on the line. It might be either AC or DC. AC varies between 50 and 60 cycles. The transformer supplied with mobile clinics is suitable to produce the step-down to suit C.D.C. electrical instruments but as the generator is not always suitable for use in buildings a converter is required when DC is the only current available. This applies to lathes, etc.

(b) Mosquito nets and bars should be added to the kits for screening windows and doors as well as for the protection of personnel in the operating room and sleeping quarters. Alternatively a personal issue to each individual would be feasible for use as circumstances required.

(c) Arasol bombs for spraying insect repellent should be issued with each kit. These can be used in screened rooms and under mosquito netting and have been found very effective in destroying insects in confined spaces.

Technical Dental Supplies

General

1. The Research and Development section of the RAF confirmed that acrylics liquid evaporates to some extent, even from sealed bottles. It was suggested that sealing wax is a satisfactory preventative. The brittleness of sealing wax is admitted, but it is felt that adequate packing is all that is necessary to make this method of shipment feasible.

2. It was also stated that only seasoned acrylics should be shipped to the tropics. The Research and Development section contend that shrinkage of approximately 10% occurs in perspex (methyl-methacrylate) when exposed to the direct rays of the sun. This is also applicable to denture bases.

3. In so far as corrosion of steel is concerned, the question of suitable plating as a preventative was discussed with the R. & D. section. The consensus of opinion is that chrome plating is the most effective, followed in order by nickel and copper. There is no effective method of protecting the cutting edges of steel instruments, and consistent daily care is indicated on the part of personnel. This does not apply to stainless steel. For shipment purposes to prevent rust in transport in the holds of ships, and exposure to sunlight on docks, etc., a light coat of vaseline is sufficient. It is also advisable to have a light wrapping of oil paper.

4. The measured temperature inside packing cases reaches approximately 160°F. in the sun. Such cases are frequently ex-

posed on docks, and in subsequent transport, to direct sunlight. These are the accepted observations of the R. & D. Section, Headquarters, Air Command, South East Asia, the Director of which is W/C J.N.C. Law.

5. It is stated that evaporation and volatilization of chloroform is considerable, even in sealed bottles, when the temperature rises above 90°F. Included in the gases given off is phosgene.

6. The U.S. Dental Corps have adopted as a policy the despatch of gold by courier via air transport. Their experience has been that gold disappeared in transit, mainly because it was shown on the manifest of the ship.

7. The policy adopted by the U.S. Dental Corps for shipment of X-ray films and volatile liquids, such as acrylic, is to ensure storage on shipboard in a room where the temperature can be controlled. If air conditioning or refrigeration space is available, use is made of it. On arrival in tropical areas, the same care of controlled temperatures is observed.

Plaster, Artificial Stone and Investment Materials

General

As a group, all plasters, stone and investment materials have a short shelf life in tropical, humid areas, if indeed, they arrive in normal condition. All packaging should be in adequately sealed tins, as cardboard containers or paper bags are useless. Ideal packaging methods would call for lacquered or japanned tins, or other rust-resistant metals, and in all cases the lids should be sealed with sealing wax, or soldered to the container, both for shipment and storage purposes. It is preferable to issue smaller sized containers, as all these materials gather moisture when the unit has been opened.

Plasters obtainable in India are entirely unsuitable for dental purposes.

Plaster - Model

The R.A.F. are shipping plaster in 50 lb. metal drums, painted inside and out with black metal paint. Some of this plaster was issued to C.D.C. Detachments through the courtesy of the R.A.F. Dental Service when shipments from C.D.C. stores in the U.K. were delayed or damaged in transit. It might be stated that one such shipment was packed in paper bags, and could not be used. However, tins are in use at the present time.

The fresh plaster obtained from R.A.F. sources sets

faster than in temperate climates, and no accelerators are required. Over a period the setting time gradually shortens, so that in from 1 1/2 to 2 months it had decreased to such an extent that a retarder - usually borax, was used to allow for working time. Plaster packaged in cardboard containers becomes lumpy, and requires sifting. It is often quite hard in the corners of the containers, and in other cases, the plaster is a solid mass.

Plaster - Impression

Plaster in the 4 lb. tins for impression purposes sets too slowly if the container has been opened for some time. When the plaster finally sets, it is inclined to flake, and sticks to the teeth. It would appear that desirable properties for impression taking have been lost. It has been observed, however, that plaster mixed with Calspar in equal quantities works very well. Calspar alone is not suitable, as it sets too quickly. Packaging should be in 1/2 lb. tins.

Artificial Stone

Stone shipped in cardboard containers from C.D.C. stores arrives with lumps throughout the package. To use it at all, requires sifting the stone. The setting time is much faster than in cooler climates, and as a result, thinner mixes are resorted to. This, of course, produces softer models. Stone is not affected by humidity as quickly as plaster, and, in any case, the setting time is slower than for plaster in some investments. Stone from newly-opened containers, when mixed thin, has approximately the same setting time as a thick mix in temperate climates. Here again, packaging in tins is indicated.

Investments

Both inlay and soldering investments deteriorate rapidly in tropical areas whether the humidity is high. This is not quite so noticeable in North Africa, where the humidity is oftentimes much lower than in India and Ceylon. The investments, as shipped from C.D.C. stores in the U.K., in cardboard containers, arrive in a very lumpy condition, and the material in the corners of the boxes is usually a solid mass. After sifting, the investment was usable for a short period, but took some time to set. The setting time gradually increased, until the investment became useless and remained a sticky mass. No definite time limits were observed for the material to reach this stage, since much depends on the humidity during different seasons.

A purchase of investment material was made from Australian sources and shipped in by air. It was found that this set rapidly, and became quite hard when the container

was first opened. Over a period, the setting time gradually lengthened and, before the 5 lb. tin was used up, the material became useless. When used as a soldering investment at this stage, boiling water washed the material away.

Conclusions

The usual issue of plaster, stones and investments as used by the C.D.C. are considered suitable in tropical climates, providing packaging in well sealed and rust-resistant tins is done.

Because of exposure to humid conditions, and the absorption of water by the materials once the containers are opened, it is recommended that smaller packages be used as follows:

Plaster - Impression	- 1/2 lb. tins
Plaster - Model	- 2 lb. tins
Artificial Stone	- 2 lb. tins
Investment	- 1/2 lb. tins

It is to be noted that the ordinary tins are subject to rust, which permits moisture to gather inside the containers, and the properties of the materials are destroyed. For that reason, protection of the tins is essential.

Steel Instruments and Burs

The observations under this heading are confined to carbon steel instruments and burs, and are the observations to date which is felt should be reported as soon as possible.

In general, all carbon steel and burs rust very quickly in India, Ceylon and, to a lesser extent, in North Africa. In lieu of listing all the instruments in the stores list, general observations only are submitted herewith.

In many cases, all materials made of carbon steel arrive with a coat of rust because of the humid condition in the holds of ships. This would indicate that careful packaging is absolutely necessary. In all cases, particularly of burs, a light coating of vaseline and additional wrappings in oiled paper should be sufficient protection against rust. The present method of packaging burs is no protection whatever, although a covering of cellophane is of some help. However, if the cellophane becomes wet, it tears easily, and permits moisture to permeate the package. If original packaging methods, as detailed above, are followed, storage becomes no problem, either in a Q.M. store or when issued to a Dental Officer, providing a rust-preventive coating is not taken off until the instruments or burs are required for use.

It has been observed that the C.D.C. Detachments in this area have all taken particular caution to protect steel instruments to the extent that they were kept continually greased until they were required for use. The burs are removed from the original package and also greased, and after sterilizing, they were again greased and stored for future use. The life of burs in these climates is much shorter than in temperate zones because of slight rusting on the cutting edges, which cannot be avoided. This would indicate additional supplies as compared with a temperate zone.

Care in the protection of steel works very well for the handles of instruments, but it is much more difficult to prevent rust on the cutting edges. In this case, continual sharpening, beyond that which is ordinarily done, is necessary, and particular attention must be given to such cutting edges. The result is that the instrument is rapidly worn out.

It has been found that chrome plating is somewhat better than nickel plating, but the ideal instrument for use should be made of stainless steel. In this connection, it is well known that it is much more difficult to retain a fine cutting edge. However, the British are at present issuing stainless steel instruments to the exclusion of carbon steel. In order to maintain the policy of the C.D.C. to provide fine cutting instruments, it is felt that, with the proper precautions, the use of carbon steel instruments can be retained. It is suggested, however, that stainless steel be substituted for all other instruments.

Contact was made with two dental supply houses in Bombay - Messrs. Powells, Limited, and Dr. Patel & Sons. It was stated that steel instruments are received quite often in bad condition in so far as rust is concerned. The manufacturers evidently do not always comply with packaging instructions as recommended by the dealers in this area. When goods are received in this condition, it is necessary to refinish or buff them. Thereafter, a coating of vaseline is kept on the instruments. Messrs. Powells, Limited, are also manufacturers of surgical and dental instruments to a limited extent, and the removal of rust is done at their factory.

Steel and Metal Fittings

This list will be confined to steel and other metal fittings for various items in the dental kit, which, it has been observed, are subject to rust and corrosion. In this instance observations on individual items are listed under a heading "A" and "B" Kits with additional data on "C" and "D" Kits.

"P-14"

"A" and "B" Kits

Cans - gasoline

- Not affected because of a thin film of oil which gathers.

Cans - oil

- Not affected.

Chair - operating, steel, folding, portable, Army pattern

- Not applicable if the moving parts are kept well oiled and the remainder of the steel kept well painted.

Engine - dental, foot, belt type, triple section arm

- Not affected unless the paint becomes scratched. The spring is subject to rust, but careful oiling will prevent a great deal of trouble. Belts are subject to rot, and do not last as long as in temperate climates.

Handpiece - straight, and contra angle, Doriot, all metal No. 4, S.S.W.

- Not affected if kept well oiled. It has been observed however, that the latch lock holding the bur in place is subject to rust around the notch. As this wears off the bur is not gripped firmly, with the result that it is inclined to seize in operation when the wear has progressed to a certain point. It does not seem possible to prevent this excessive wear, and it is recommended that additional latch locks be supplied.

Lantern - pail for No.242, Coleman

- Not affected

Lantern - Sport Lite, No.242B, Coleman

- The screw top rusts quickly, but the remainder of the metal parts are not affected. This screw top cannot be kept oiled, since the heat burns it off.

Stove - one burner, No.550,
Coleman

- Superstructure, except the burner, rusts quickly, and cannot be oiled or painted successfully. Generators deteriorate, and the usual expenditure is about 5% per annum. The gasoline obtained is generally suitable. However, it is more difficult to obtain lead-free gasoline from Army Units.

Stool - steel, folding, Army
pattern

- Joints are subject to rust, but oiling is a satisfactory preventative. Other metal parts are not affected if kept painted.

Table - folding, field, Army
pattern

- Joints are subject to rust, but oiling is a satisfactory preventative. Other exposed parts stand up well if kept painted. The plywood top warps badly, even if painted.

Holder - cotton, metal

- Not affected.

Syringe - water, dental,
Spooners' quick filler

- This item lasts about two months in Ceylon because the rubber softens and deteriorates in that length of time.

Scissors - crown curved, Beebe
No. 11

- Rust at the joints, otherwise not affected.

Scissors - 2 5/8 x 6, nickel-
led, No.124X, Clauss

- (Same as scissors above)

Syringe - hypodermic, local
anaesthetic

- The thread portion rusts and corrodes, with consequent wear, otherwise not affected.

Brushes - tooth, polishing

- Not affected.

Cup - rubber, polishing,
straight H.P. and con-
tra angle H.P.

Syringe - chip, No.22

Bands - copper and matrix

Broach - root canal, unmounted

Disks - paper, all types

Disks - separating, car-
borundum, 7/8" regular

Mandrels

Reamer - root canal

- The black rubber de-
teriorates rapidly, and
the white ring becomes
soft, sticky, and use-
less. The mandrel is not
affected.
- The rubber deteriorates,
otherwise not affected.
- A slight coating of ver-
digris occurs in due
course, otherwise not
affected.
- Because of poor packag-
ing, these have never
reached the Dental Of-
ficers in Ceylon in good
enough condition to be of
use, because of rust and
corrosion.
- Not useable at all once
they become damp. The
grit comes off, and the
binder turns to a pulp.
They cannot be dried at
the chair successfully.
Use is made of finishing
stones in lieu of paper
disks.
- Can be used successfully,
but the binder does not
stand up as well as in
temperate climates. It is
estimated that approximate-
ly six to one is the ratio
as compared with normal
usage.
- The screw portion of man-
drels rust and corrode to
such an extent that they
quickly become useless.
- Rust badly, and become
useless.

Carrier - amalgam, gun,
Clev-Dent

- The spring is subject to rust, but light oiling is a satisfactory preventive.

Clamp - rubber dam No.2A
and 56, Ivory

- Not affected.

Forceps - rubber dam clamp,
Brewer Universal, S.S.W.

- Not affected.

Gauge - alloy mercury, adjustable type Caulk

- Do not deliver proper proportions. This may be because of dampness preventing the flow of alloy.

Holder - broach

- The thread is particularly subject to rust.

Holder - cotton pellet,
beehive

- Not affected

Holder - rubber dam, No.8,
S.S.W.

- Not affected.

Lamp - annealing, alcohol,
No.1

- The wick turner rusts quickly.

Strip - finishing, linen,
garnet

- The Moyco product is not considered satisfactory, especially in fine grit. Kraftex, made by Reliance Dental Co., Chicago, are much better, and are satisfactory for the purpose.

Case - Jaw Injury Kit

- The leather covering is just about useless in tropical areas because of mould. In addition, the white ants attack the wood under the leather, and the case becomes useless.

Paper - articulating thin
Mynol

- Not affected.

Files - all types

- Subject to rust, with the result of impaired efficiency in so far as cutting edges are concerned. In this instance, greasing is of little value, and packaging in oiled paper is indicated.

Guide - plane, occlusal,
Fox

- Not affected.

Guide - shade tooth, 20th
Cent.

- Not affected.

Torch - mouth Trench

- Rubber deteriorates.

Trays - impression, and
Crown and Bridge

- Not affected.

Basin - rubber, Army
pattern

- Rubber deteriorates.

Sterilizer, field, English,
Army Pattern No.2

- The metal portion around wicks rust very quickly. In addition, it has been noticed that where fans are in use in static units it is almost useless, since the flame, being blown against the alcohol container, causes the whole to heat to such an extent that it catches fire. This is in spite of protection on the back and two sides. As fans are in operation most of the time to keep temperatures within a working range, the Colemans are preferred, and even in this instance, shields of metal are used to keep the flames from being blown by the fan.

Battery box for head-
lights

- This box rusts quickly, and the hinges break off.

If the batteries are not cared for, and in continuous use, they swell with the dampness, and become useless. It is to be noted that batteries are difficult to obtain, and where obtainable, they must be stored in thin rubber, such as rubber dam, to keep them dry.

"C" and "D" Kits

Blowpipe - gasoline

- Not affected because of a thin film of oil which gathers on the metal parts.

Lamp - alcohol, Bladon

- Not affected.

Spatula - wax

- Not affected to any extent.

Tweezers - soldering

- This item rusts badly in spite of precautions against corrosion.

Can - gasoline

- Not affected.

Funnel - filter

- Not affected.

Holder - flask, wax, boiling, Army pattern

- The thread on the screw, as well as the spring, are both subject to rust, and wear out quickly. Oiling does not seem to be feasible. Otherwise not affected.

Stove - 1 burner, No.550, Coleman

- (Refer to this item under "A" and "B" Kits)

Flask - vulcanite, brass

- Not affected.

Ladle - metal, melting

- Not affected.

Band - abrasive, for chuck arbor

- The life of this item is short. It becomes

Sandpaper - all grits

Saw - mechanical, blade
metal cutting

File - gold, half-round
4" XF Swiss Pattern,
Cut No.2

File - vulcanite, double-
ended, half-round, rough and
bastard

Saw - frame, mechanical

Scrapers and Trimmers

Cone - felt, pointed

Pumice - Rouge and Tripoli

soft with dampness, and the abrasive comes off easily. However, it can be partially dried out over a flame, and lasts fairly well. In this instance, double the normal issue would be satisfactory.

- This item is absolutely ruined by too much moisture and dampness. However, continual care in keeping the sheets dry is all that is required. Packaging in waterproof paper should be sufficient.

- The blades of this item rust very quickly, and become useless. If properly packed and greased before shipment, there should be no trouble. Again, a double issue is indicated.

- Useful life of this file is short because of rust. The effectiveness of oiling is very doubtful, and packaging in oiled paper is indicated.

- Same observation as for file above.

- Subject to rust, but oiling is satisfactory preventive.

- All subject to rust. Oiling is of value, but constant care must be exercised.

- Not affected.

- Not affected.

Wheel - abrasive,
flexible

- The abrasive in this wheel stands up well, but the wheel itself becomes quite soft.

Wheels - brush, all types

- The metal centre of these wheels rust badly and break off from the surrounding cone, consequently ruining the wheel, and allowing the bristles to come out.

Wheel - buff, sewn cotton,
shellac centre

- Not affected.

Wheel - polishing, chamois
leather

- Not affected, but if not stored properly are subject to mould. If proper care is exercised, there is no difficulty.

Base - trial, upper and
lower, regulation

- All issues except Climax - made by the Associated Dental Co., in England, stand up all right. The latter was not considered good quality.

Articulator - Gysi Simplex

- The springs on these articulators rust, with consequent breakage, in spite of light oiling. Extra springs should be issued.

Vulcanizer - Lewis X-Bar

- Rusting has not been observed, except on the cover.

Acetone - bottle

- The liquid evaporates quickly once opened. Smaller items of issue would be of advantage.

Flux - for stainless steel,
wire, jar

- Hardens very quickly once the container is opened, but this can be corrected by a drop or two of water plus HCl. Smaller items are indicated.

- | | |
|--|--|
| Wheel - felt, for metal work | - Not affected. |
| Pliers - all types | - Rust quickly. |
| Wire clasp - gold, high tensile, all types | - Not affected. |
| Wire clasp - stainless steel | - Becomes pitted, although extensive rust is not discernible. In this instance, no microscope was available to determine exactly what happened to the wire. However, this has not been observed on stainless steel lingual and palatal bars. |
| Articulator, crown and bridge, and inlay | - Subject to rust. |
| Machine, casting, Centrifugal Perfection | - The spring in this machine rusts to some extent, but this item should stand up for reasonable periods of time. |

Local Anaesthetics

For utility and satisfactory results, the use of carpules, cartridges or ampules is definitely indicated.

2. Some supply houses state that the tropical shelf life of cartridges, carpules and ampules is approximately two years. However, present information is that shipments are arriving which show definite deterioration, with the result that there is considerable wastage. However, the available opinions are to the effect that shelf life is much shorter because of the hot, humid conditions in the holds of ships, together with similar conditions while the goods are stored in QM Departments before issue.
3. Packaging of local anaesthetics must be leak-proof to water and air. The covers of tins, where used, should be sealed as an added precaution.
4. All shipments to tropical areas must be from freshly prepared goods direct from manufacturers, to ensure the shortest possible storage time and shelf life before the stores are actually used. Shipments from Canada, for instance, would take approximately three months to reach India or Burma. Similarly, the

anaesthetics should be issued as soon as possible by rotating the stocks.

5. Storage in tropical areas before issue should be in a cool, dark room. The U.S. Dentals are using air conditioned rooms for this purpose in Calcutta.

Alloy and Mercury

The properties of alloy and mercury are not affected by heat and humidity. There is evidently little change in the mixing or setting time, while the resulting filling is identical with those inserted in temperate climates.

2. It has been observed that more scum forms on the surface of the mercury, but this does not seemingly affect its properties.

Denture Materials

(1) Vulcanite

Vulcanite has been found to be satisfactory in tropical areas both from the standpoint of shelf life and processing.

(2) Acrylics

(a) It has been observed that the liquid supplied with acrylics evaporates from sealed containers. Evaporation is much greater after the container is once opened, and attempts to prevent this by re-sealing with wax, sealing wax, etc., have not been effective.

(b) The powder component of acrylics is not affected by either temperature or humidity, if properly sealed. Extra precautions are required for shipment in the holds of ships where heat and humidity is high.

(c) Cooling of flasks, liquid and powder, before packing has met with a measure of success in the case of one technician. After boiling out and cleaning with cotton dampened in chloroform, the flask is placed in an ice cooler until thoroughly chilled, perhaps to 40° F. The cooled flasks are placed on the bench, face up, and covered with a thick towel to prevent the formation of moisture on the surfaces. Any remaining moisture which does form, is wiped off with cotton dampened in chloroform. The mixing jar containing liquid and powder is also placed under the towel between the flasks. Union of powder and liquid occurs approximately within 12 or 13 minutes. It is then stirred rapidly and packed quickly, just as the stringy stage is reached. It is preferable to attempt an accurate estimation of the amount of acrylic required, and

so eliminate trial packs. Even with the above precautions, cases are packed in the comparative coolness of the early morning or evening.

(d) Liquid cooled alone in the above manner tends to become milky and remains so for some time. Finally, it does not become a clear liquid again. This may be due in part to traces of moisture.

(e) Powder cooled alone in the mixing jar, sticks to the sides of the jar, evidently because of traces of moisture, also.

(f) When cooling procedures are not available or have not been used, considerable difficulty has been experienced in processing. For instance, the mix seems to harden to such consistency that addition to the material after trial packing is most difficult. It is further complicated by a crust-like film which forms on the surface of the material after the first trial pack. A true blending of shades is also difficult to obtain. The foregoing observations are the experiences of the technician in Calcutta, under working conditions averaging approximately 100°F., with high humidity and a large ceiling fan in operation. Such working conditions would not obtain in the forward areas, and high temperatures would be encountered.

(3) Conclusions

(a) For processing dentures in the advanced forward areas, the use of vulcanite is considered more feasible than acrylics, although with care and ingenuity, acrylics can also be completed.

(b) For shipment it would be advisable to provide for adequate sealing of bottles of liquid more effectively than is now the case. For storage purposes in tropical areas, a cool, dark room is considered sufficient.

(c) Working conditions at bases such as Calcutta are much more favourable than the forward areas for processing, and in spite of some difficulties, it can be done successfully.

(d) Careful packaging and storage of acrylics is indicated, particularly the sealing of liquid bottles.

(e) It is suggested that investigation be carried out to determine whether there is a chemical change in the liquid for acrylics when some evaporation takes place.

(f) Subject to further study, it would appear that the establishment of central laboratories where cool, well-

ventilated accommodation is available should be adopted as policy in so far as prosthetic work is concerned. This would eliminate service in the more advanced forward areas for the construction and repair of dentures. However, the advanced dental officers can establish a line of communication to forward impressions to the laboratory by air, or otherwise. In some cases, the patient can be despatched to the laboratory location for treatment. This is being done on a fairly large scale by both the U.S. and R.A.F. dental services.

Dental Waxes

(1) Base Plate Waxes: Base plate waxes in general use in temperate climates are not entirely suitable in tropical areas. For example, Caulk's red base plate is too soft and is difficult to carve and is considered useless except for bites or bite blocks over baseplates. Ash's Nos. 3 and 4 act similarly to Caulk's although they are a bit tougher. Both types of wax shrink when cooled rapidly. As a result, they pull away from the model and often crack. Thus, the teeth are pulled out of place because of distortion, particularly on the palate of the uppers.

In addition, shipments of these waxes often arrive as one solid mass and, even under favourable conditions, each sheet is inclined to stick to the next, and to the paper between the sheets.

The use of Ash Model Cement Wax for holding teeth in place improves conditions somewhat in so far as waxing up dentures is concerned. However, a film remains on the teeth, clasps and model after boiling out and oftentimes results in loosened teeth and clasps in the finished denture.

Most of the waxes now on issue harden slowly once they have been softened by heat and seemingly never reach their original consistency. Where possible, the waxed up models and impressions are kept in refrigerators but the wide range in temperatures causes excessive shrinkage. Tougher waxes are desirable, even if baseplate is used as a base for bite blocks, etc.

It is recommended that a wax, such as Ash No.2, S.S.W.No.9 Pink, Tuf-flax (Mizzy) or Caulk's Hi-heat No.158 be provided for tropical climates. The first named has been found satisfactory by the British Army Dental Corps and the latter two are in use by the U.S. Dental Corps and the Royal Navy Dental Services. Issue of these types of waxes should be instituted at once for the Detachments in the Middle and Far East.

(2) Inlay Wax: It has been observed that dry heat for softening Kerr's Blue Inlay Wax is not as satisfactory as the hot water method. Again, this wax takes longer to harden and is rather more difficult to handle than in temperate climates. However, with careful manipulation, the blue wax is satisfactory and no change is recommended. Caulk's inlay wax is not considered to be as good as Kerr's because of difficulties in carving and poor flowing qualities.

Synthetic Porcelain

1. Observations on the suitability of synthetic porcelain fillings which have been inserted under tropical conditions, i.e., temperatures varying from 80° to 110°F., in the shade, coupled with either high or low humidity, are to the effect that they do not stand up in the mouth. Fillings have to be replaced in a surprisingly short time, and many become loose or appear to be in a state of disintegration. "Washing" from the cavity is a much more common fault as compared with fillings inserted in temperate climates. This is more marked around margins of the cavity.

2. The setting time of the mix is very rapid and this does not permit spatulating to proper consistency. The tendency is to use thin mixes so that the material can be transferred from slab to cavity before crystallization sets in. Even then, it is quite hard three minutes after mixing and, once the initial stage of setting has been reached, the process comes to completion almost immediately.

3. After 24 hours, when the patient returns to have the filling polished, it was found that the use of medium cuttle strips with vaseline as a lubricant reduced the contour of the filling much more rapidly, than is usually the case. This indicates a soft filling.

4. One or two days after polishing it was observed that many thinly and thickly mixed fillings had already developed minute margins.

5. A stiff mix is certainly to be desired, but the difficulty is to pack the material in the tooth before it becomes non-workable. In any case, such fillings also show erosion to a marked degree.

6. Attempts were made to chill the slab, and this is satisfactory where ice is available. Condensation on the slab can be avoided by carefully drying with a towel and quick manipulation of the materials. Attempts to cool the slab with water from the tap are not very successful, since the temperature of the water is almost equal to room temperature.

7. Many dental officers have resorted to the use of amalgam for filling anterior teeth in preference to the synthetic porcelain, providing the appearance was not too obvious.

8. Perhaps the solution to the difficulties encountered could be referred to the manufacturers and a retarding agent added to the liquid for use in tropical areas.

Dental Clinic Accommodation

Static

None of the forces in India or Ceylon have made provision for the construction of dental clinic buildings to standard specifications. Use is made of buildings already erected either permanent or temporary and later adapted for the purposes. The only example seen by the writer was the C.D.C. clinic in Koggala, Ceylon.

In centres such as cities and towns, requisitioned buildings are in general use for all purposes. Most of these are constructed of brick and stucco with a view to coolness, eliminating glare, and for protection against heavy rains during monsoons. The architecture is Oriental in design with thick walls protected by extensive columned verandahs. The windows are small and shuttered. Consequently, the rooms are dark and artificial light would be a necessary adjunct for dental operating. There are, of course, exceptions to these conditions, but the space is usually already utilized by some other department. In most places, overhead electric fans are already installed.

Buildings of temporary construction are of brick or the basha type. The former are constructed entirely of brick including the floors. Again windows are small and in addition to shutters are protected on top by a small canopy. In the case of the latter, the construction is of bamboo poles erected perpendicularly in the ground and the side walls made of palm or banana leaves. The roof is thatched with palm leaves and an air vent of approximately 6 inches is provided between the side wall and the thatch. In this type of construction, the doorway acts as a window in most cases. The basha hut can be erected in forward areas in a matter of hours by the use of native labour.

Very few of the permanent or temporary buildings are entirely suitable for dental purposes both from the standpoint of light and the general layout of rooms. They can, however, be adapted where artificial light is necessary the year around.

There is the additional problem in the temporary buildings of eliminating the myriads of insects which are attracted by the light and are a considerable nuisance whether artificial light is being used or not. Adequate screening for dental operating rooms is essential for asepsis and the comfort of both patient and operator. Mosquito bars should, therefore, be added to the dental kit as an issue for use in the operating room.

It is felt that existing buildings should be used as dental clinic accommodation in the rear areas because construction facilities and supplies are entirely controlled by the Indian Government and let to private contractors who use native labour. A programme of construction would bog down before definite results could be obtained.

With regard to the forward areas, the basha huts can be quickly constructed providing labour is available. In any case, at a wing headquarters for example, a number of such huts are made available and they can be quickly adapted for dental requirements. Tents are also available and can be utilized in many instances. Here again adequate screening and mosquito bars is essential.

Mobile

Because of the lack of roads and road conditions, particularly in the forward areas, only a limited number of mobile dental clinics can be used. It is suggested that only 25% of the normal establishment for mobile dental clinics be issued for tropical services, so that the officer commanding the company can plan the type of accommodation suitable for the area being served.

If amphibious operations are undertaken, mobile clinics will not be required until such time as large areas have been consolidated as a bridgehead, and should not be included on the establishment. However, they can be made available if required for a war of movement.

Elsewhere in this report, suggestions are outlined for the necessary modifications to the existing lorries to make them suitable for tropical areas.

Charts of Temperatures and Humidity in the India,
Burma and Ceylon Areas

Monthly Average Maximum Values of Temperatures
and Humidity at Calcutta and Rangoon

Month	<u>RANGOON</u>		<u>CALCUTTA</u>	
	Mean Max. Temps.	Mean Rel.Hum. at 0800 hrs. (approx. max.)	Mean Max. Temps.	Mean Rel.Hum. at 0800 hrs. (approx. max.)
January	91	72%	77	85%
February	94	77%	83	87%
March	97	80%	93	81%
April	98	81%	95	79%
May	92	85%	100	77%
June	87	90%	95	80%
July	85	92%	90	88%
August	87	90%	89	89%
Sept.	85	91%	89	89%
October	89	86%	91	82%
November	89	83%	86	79%
December	89	80%	80	83%

- Note: 1. In winter months, high relative humidity at both places occurs when temperatures are at their lowest.
2. In monsoon months, there is little diurnal variation in the relative humidity.

Monthly Temperature and Humidity Range - Ceylon

Month	<u>Temperature</u>		<u>Relative Humidity</u>	
	Maximum	Minimum	Average	%
January	89	67	78	92
February	91	69	79	90
March	92	71	81	90
April	90	71	81	89
May	88	71	81	87
June	86	71	80	87
July	85	71	80	88
August	85	70	79	88
Sept.	85	72	80	87
October	87	70	79	90
November	87	71	79	91
December	89	66	78	92

Note: The temperatures given are screened temperatures.

Packaging Methods

1. The problem of the packaging of supplies and equipment has not been extensively surveyed in this theatre except from some local standpoints. It is only comparatively recently, that any action has been taken to improve matters in this regard. The tendency has been to accept goods as shipped and make the best of it. The result has been loss and deterioration on a considerable scale. Investigations, however, are being carried out elsewhere, and local observations have been forwarded by G.H.Q., India, to the Committees responsible for the research on these matters.

2. The problem of packaging falls into two parts -

- (a) Initial packaging for the transport by sea or air to a port or base in the C.B.I. theatre, and thence to a supply depot.
- (b) Packaging for issue to units.

These two points should be identical from the standpoint of the protection of individual items of dental supply and equipment against tropical conditions. In other words, it would be advantageous if as many items as possible could be shipped completely protected so that packages can be issued to D.O.'s without being opened. For some items, this is essential. For example - burs and broaches.

3. The effective supply line in India as far as rail is concerned, must be kept in mind. Transportation facilities are inadequate and mostly inefficient. There are three different railroad gauges - broad, metre, and narrow. Goods starting out in a 20-22 ton capacity broad gauge car have to be unloaded and reloaded into narrow gauge cars which have a capacity of only 12 tons. This is repeated when the numerous rivers and streams have to be crossed by ferry. Because of the volume of traffic of a few railroad lines, it takes much longer to move goods from one section of the country to another, and oftentimes because of frequent handling en route, equipment never reaches its destination. To move supplies from Karachi to the forward area, a distance of about 2000 miles which would be a two-day job in Canada, required anywhere from 30 to 60 days. It was noted also that many rail cars are the open flat type, and goods are exposed to all the varying weather conditions.

4. Transportation by road is not highly developed nor is air transport used on a major scale at present. No doubt an increase in air transport freight service will be effected if larger scale operations are undertaken.

5. The weight and size of packages for distribution in forward areas is important as transport may in the final analysis be by means of pack-animal or coolies. The weight normally carried by a mule is 60 lbs. on each side, and by coolies a total of 40 lbs. Cases may be of wood or the individual items packed in panniers. In any event, the container should be as light as possible consistent with durability to withstand rough handling. Interior protection against insects and dampness is essential.

6. It would appear that individual items of supply and equipment must be packaged according to their resistance to weather conditions. Elsewhere, in this report, those items affected by the climate are listed, and consideration of packaging should be given to each item. The type of packing case for shipping by sea, is dealt with elsewhere.

APPENDIX "Q"

INTERIM REPORT TO THE ASSOCIATE COMMITTEE ON DENTAL RESEARCH

October, 1947

Subject: A study of the use of periodontal cement packs in the prevention and treatment of disease of the supporting tissues of the teeth.

Grantee: H. K. Box

Project No. DR 4 Amount of Grant: \$2,200.

The following is a progress report of two studies being carried on relating to the main problem under DR 4.

Study 1

An investigation of the mechanisms involved in the regeneration and reattachment of the supporting tissues of the teeth lost through periodontal disease.

One result of periodontal disease is the progressive destruction and loss of the supporting tissues of the teeth. Whether these tissues can regenerate and become reattached to the tooth is a moot question. Skillen and Lundquist (1937) Coolidge (1946), Black (1915), Orban (1943) and Kronfeld (1933) stated that reattachment had not been demonstrated and believed that the detachment of the periodontal membrane from the root is permanent. On the other hand Gottlieb (1943), Box (1928), Leonard (1943), Noyes (1912), and Merritt (1945) believe that functional reattachment may occur. Leonard states that this problem has been a controversial subject since 1894.

Periodontal disease is responsible for the loss of as many adult teeth as caries. Generally the teeth are extracted when insufficient periodontal membrane and bone remain to support the teeth during mastication. Thus, this problem is an important one from the dental point of view.

The study was carried on using dogs as experimental animals. As yet few sections have been made. This point should be borne in mind when considering the report.

"Q-2"

(1) Under experimental conditions, reattachment of the soft tissues after a part of the alveolar bone and soft tissue has been destroyed, is found to occur fairly uniformly. The problem of their reattachment is being studied to determine the factors involved - those essential for reattachment and the conditions favourable and unfavourable to the regeneration of the tissues concerned, e.g., the periodontal fibres and the new cementum to attach them to the tooth.

(2) Having found that the soft tissues were capable of reattachment, the regeneration of alveolar bone was also investigated. A procedure was devised which permitted the regeneration of the alveolar bone, 6 to 8 mm. of alveolar bone being regrown in about six weeks. The new bone seemed fairly well developed but slightly darker than normal in colour. The mechanisms involved in this regeneration are being studied.

(3) Based on the above findings, the main problem of the regeneration and reattachment of the supporting tissues in the treatment of periodontal disease is being investigated. Periodontal pockets are experimentally produced for this purpose. Again the factors involved are being studied. Some progress has been made.

One dog in which a periodontal pocket had been produced, developed a bacterial flora very similar to that found in necrotic periodontitis. The smears showed many of the *Leptothrix falciformis* besides the usual groups of organisms found in deep periodontal pockets. The gingiva was quite inflamed and tissue destruction appeared to be proceeding rapidly. An attempt was made to repeat this in another animal to study the life cycle of the *Leptothrix falciformis*. A large pocket was produced and smears were taken daily for some time and then weekly. The pocket remained almost sterile for a considerable period and so far has not developed a bacterial flora differing from what is found around healthy teeth. This suggests that factors other than just the formation of a periodontal pocket are necessary for the development of the pocket flora commonly associated with periodontal disease. Further investigation is being carried on as this point may have some bearing on the necessity for the eradication of pockets in treatment.

Study 2

The second study is an investigation of the effect of changes in physical character of the diet, on the growth and development of the skull. The study was carried out using rats as experimental animals. The quality and quantity of the diet was the same for all groups of animals.

"Q-3"

This study is partly the result of a visit to a school in Welland at the request of the Public Health Committee of the Ontario Dental Association. The Red Cross Society is endeavouring to develop a model health unit there, including dental and medical services. During the day a number of children were examined. Among other things, many of the children presented facial deformities seemingly due to faulty growth and development. Facial deformities are well known to be a hazard to the mental and physical health. I believe that dentistry has a responsibility to these children and that this field presents a further opportunity for service.

It seemed to me that the physical character of the diet, apart from its quality and amount, has a part to play in the normal development of the skull. I talked this possibility over with Dr. Best and with his permission and help, a study was planned using experimental animals to test this hypothesis.

The study has been in progress since last January. Half of the animals have been killed and their skull development studied. Results seem to indicate that the hypothesis on which the work was planned, is substantiated to a degree greater than expected. However, any definite statements are premature at present.

I may say that this study has led me into a fascinating new field. It is possible that it will throw some light on the effect of mal occlusion and mal function on the supporting tissues, which is an important and controversial subject in dentistry.

This report was prepared by Dr. W. J. Linghorne who conducted all the experimental work outlined above.

October, 1947.

APPENDIX "R"

(i) By-Law respecting National Research Council
Committees,

and

(ii) Basic Terms of Reference for Committees
approved at the 161st meeting of Council
held 12 September, 1947.

NATIONAL RESEARCH COUNCIL

By-Law respecting National Research

Council Committees

1. Each Committee established by the National Research Council shall be assigned one of the following official titles:

- * "The Associate Committee of the National Research Council on, or
- "The Special Committee of the National Research Council on....., or
- "The Standing Committee of the National Research Council on

* The functions of an Associate Committee within an assigned field may be entirely advisory or they may be advisory combined with responsibility for the planning and supervision of research work within the assigned field.

The functions of a Special Committee shall be similar to those of an Associate Committee, the main difference shall be in the degree of permanence of the proposed activity and/or its degree of importance.

A Standing Committee shall be a Committee of the National Research Council with a membership which is composed exclusively or mainly of members of the National Research Council.

* 2. The terms of reference, the membership and the appointment of a Chairman and of a Secretary of an Associate, Special or Standing Committee may be fixed and revised from time to time, as required, only by the National Research Council.

* 3. A concise statement of the purpose for which a Committee has been appointed shall be recorded when it is being established.

* 4. The members of a Committee shall be chosen, when practicable, primarily for their technical knowledge and experience and/or the contribution which they can make to the work of the Committee. Members shall serve without remuneration and, other than ex-officio members, shall be appointed for a term not exceeding three years, expiring 31st March in a specified year. The National Research Council shall determine in the case of each committee whether or not retiring members should be eligible for immediate reappointment.

The President and the General Secretary of the Council shall be ex-officio members of all Committees.

5. The Chairman of a Committee shall be responsible to the National Research Council through the President, for the direction of all activities undertaken by the Committee, and for the submission annually of a report covering all such activities, or at such more frequent intervals as the President may request. The Chairman shall convene meetings of the Committee when necessary, and shall preside at such meetings, and shall be responsible for insuring that an orderly and correct record is prepared of all questions discussed and decisions reached at meetings of the Committee.

6. Travelling expenditure should be authorized in advance by the Chairman of the Committee, including that connected with meetings of the Committee and of all subcommittees.

7. The Chairman of the Committee shall submit to the President not later than 1st October each year, an estimate of the financial requirements of the Committee during the fiscal year beginning 1st April following. This estimate should furnish such details as may be practicable and should show the amounts requested for:

- (a) Grants in aid of research projects
- (b) Travelling
- (c) Other purposes.

Similar details respecting the financial requirements for each subcommittee (if any) should also be given.

8. The Secretary of a Committee shall be responsible for assisting the Chairman in any way practicable in the administration of the activities of the Committee. When requested by the Chairman he shall notify members of meetings of the Committee and shall make all necessary arrangements therefor. He shall attend all meetings of the Committee and make an accurate record of all questions discussed and decisions reached, and he shall receive a copy of all documents presented for consideration by the Committee. He shall submit his draft minutes to the Chairman of the Committee for approval or necessary revision. On approval of the minutes by the Chairman, the Secretary shall prepare and shall forward a copy of the complete proceedings of the meeting to the Chairman and members of the Committee, and to the President and the General Secretary of the National Research Council, and to such other persons as the President may direct from time to time.

It shall also be the responsibility of the Secretary of a Committee to notify all persons concerned of all decisions reached or action taken by the Committee. (For this purpose, it is not sufficient merely to distribute a copy of the minutes).

The Secretary of a Committee shall follow the general policy of the Council with respect to the administration of Committees, and shall observe any instructions which may be issued from time to time by the National Research Council for the guidance of Committees.

9. Grants in aid of research awarded by a Committee shall be subject to the Assisted Researches regulations and procedures of the National Research Council. The General Secretary of the Council shall be promptly informed of each such award by the Secretary of the Committee, and furnished with the original copy of the covering application for the official records of the Council. The General Secretary shall report such grants to the Standing Committee on Assisted Researches.

10. Travelling expenditure is not a proper charge against a research grant awarded by a Committee unless the applicant has shown clearly that such expenditure is essential to the research work proposed, as for example, in the case of essential field work.

11. Reports covering research projects carried on under the auspices of a Committee shall be secured at least annually by the Committee. Following acceptance of such reports by the Committee, they shall be forwarded by the Secretary of the Committee to the Director of Information Services of the Council for purposes of record and safekeeping.

Any report which contains secret or confidential information shall be clearly so marked according to classification.

12. A Committee may be empowered by the Council to appoint Subcommittees and to fix the terms of reference, and to appoint the members, the Chairman and the Secretary of each Subcommittee, but these powers may not be delegated by the Committee to a subcommittee. Action appointing a subcommittee or revising its terms of reference or its membership, or its officers, shall become effective only after the Secretary of the Committee has formally notified the General Secretary of the National Research Council of the action taken by the Committee, and has furnished the General Secretary with a copy of the terms of reference, a list of the members and names of the Chairman and of the Secretary of the subcommittee concerned, or of any revisions thereof.

13. The General Secretary of the Council shall be responsible for the overall guidance and correlation of the administrative activities of the Committees of the Council, in accordance with the policies and procedures fixed by the Council from time to time. Consequently, the Secretary of each Committee shall promptly inform the General Secretary of all administrative action taken by the Committee of which he is Secretary, and shall consult the General Secretary regarding questions of policy and procedure.

14. The basic terms of reference, as set forth in the attached appendix, shall be assigned in so far as applicable and practicable to all Committees appointed by the National Research Council.

NATIONAL RESEARCH COUNCIL

Basic Terms of Reference for Committees

In these terms of reference, the word
"field" shall mean the field of *Dental Science*
"Committee" shall mean the Associate (or Special) Committee
on *Dental Research*
"Chairman" shall mean the Chairman of the Committee
"Secretary" shall mean the Secretary of the Committee
"Council" shall mean the National Research Council
"President" shall mean the President of the National
Research Council
"General Secretary" shall mean the General Secretary
of the National Research Council.

The Associate Committee on *Dental Research*
is hereby assigned the following terms of reference.

1. To further research work in Canada in the assigned field.
2. To serve in a liaison capacity between the Council and governmental, educational and other organizations or agencies engaged in, or concerned with research in the assigned field.
3. To investigate and review when necessary the facilities which exist in Canada for research in the assigned field.
4. To prepare when necessary a list of specific projects in the field on which research should be undertaken in Canada.
5. To prepare and submit to the Council prior to 1 October each year an estimate of its total financial requirements (including subcommittees) for the fiscal year beginning 1 April following.
6. Within the limits of the funds allotted to the Committee each year, to award grants in aid of specific research projects to persons competent to direct such projects, and who have Laboratory facilities at their disposal. *suitable*
All such awards are to be reported immediately to the General Secretary for the information of the Standing Committee on Assisted Researches.
7. To secure from the director of each project an annual report and such other reports as the Council may require, review such reports and pass them to the Director of Information Services not later than dates to be specified.

8. To make recommendations to the National Research Council on any question within these terms of reference, when in the judgment of the Committee this is desirable or necessary.

9. The Committee, subject to the approval of the President, may appoint subcommittees for the more effective prosecution of its work. The Committee shall submit specific terms of reference for each subcommittee which it proposes to appoint and shall appoint its members, its Chairman and its Secretary.

Following the appointment of a subcommittee, the Committee shall inform the General Secretary promptly, and shall furnish him with a copy of the terms of reference and a list of the members and the officers of the subcommittee and of any changes therein which are authorized from time to time.

No classified information shall be disclosed to the officers or members of a subcommittee unless and until the General Secretary has been formally advised of the intention to do so and the Committee has received written advice that the President approves the proposed action.

10. The Committee shall prepare and submit to the President of the National Research Council on or before 28 February each year, a report covering the activities of the Committee during the preceding calendar year and shall attach thereto a list of the members and the officers of the Committee and of each subcommittee in existence on the said date.

APPENDIX "S"

SUMMARY OF WORK ON THE DEVELOPMENT OF A TREATMENT OF "TRENCH MOUTH" BY NATIONAL RESEARCH COUNCIL

Early in the war Dr. Linghorne noted that a mixture of seven parts of 3% H_2O_2 with one part of Fowler's solution would clear up even severe necrotic cases of Vincent's infection very rapidly (two-three days) while either material used alone was very slow and required a great deal of dentist's time to treat individually the many cases of this condition.

Unfortunately the above mixture etched the teeth badly and efforts to correct this difficulty were not successful. At this point the National Research Council was approached to attempt to turn this observation into a treatment which would retain its effectiveness, would not etch the teeth and would be suitable for use under Army conditions, preferably in a form which could be issued to the patient, and would therefore require less dentist's time.

Now the above mixture is not really a mixture in the ordinary sense, since the arsenite in the original Fowler's solution is oxidized to the pentavalent form, or the arsenate. (The solution also becomes strongly acid, but this is easily corrected with a suitable buffer). However even after neutralization, the neutral inorganic arsenate solution still etches the teeth, since arsenates and phosphates are isomorphous; the arsenate replaces the phosphate in the surface of the teeth and is subsequently removed by the saliva. Thus attack, on repeated use, is just as effective as if an acid were present. Combatting this replacement reaction was therefore one of the major items requiring attention.

Extensive experiments were therefore undertaken, and methods of preparing solutions supersaturated with calcium and magnesium phosphates were found, first from several separate solutions, and after considerable work, also from a dry powder. (It is axiomatic that solids will not dissolve past saturation but nevertheless by using a "trick" mixture this can be accomplished in this case).

These mixtures were tried clinically by the Canadian Dental Corps and found excellent, and being compounded from readily available materials, the first recipe using separate solutions was adopted immediately while work was continued on many other phases of the subject.

At this time many clinical tests were made of other recipes intended first, to attempt elimination of the arsenic,

"S-2"

by the use of other antiseptics used with hydrogen peroxide; second, to eliminate the liquid hydrogen peroxide and substitute sodium perborate, for its greater ease of storage and transportation.

However although many tests were made along both of these lines no other antiseptic was found of any special value, and perborate will not substitute for peroxide. Urea peroxide is a satisfactory substitute for the liquid H_2O_2 , but under wartime conditions it was decided to continue the use of H_2O_2 since it is well understood and generally available.

Numerous efforts were also directed towards finding a "wetting agent" which would produce a foam in a solution with so much calcium, on the idea that it might assist penetration and also by the "stiffening" effect of a foam, assist the lifting of debris from the pockets of infection. When a suitable foaming agent was found it gave a noticeable clinical improvement, and it was consequently incorporated in subsequent treatments.

At the special request of the Canadian Dental Corps a great deal of time was spent attempting to turn the dry powder, of the above recipes, into tablets in order to eliminate the storage of the gelatin capsules in which each treatment was packaged. This point unfortunately proved extremely troublesome since the ingredients reacted on each other in the tablet, due to close contact, and resulted in an insoluble mass of calcium phosphate. However, methods were finally found by which stable tablets could be prepared, but unfortunately all efforts, kindly made by the cooperation of the Chas. E. Frosst Co., to adapt the necessary technique to commercial production, failed. The tablets were never satisfactory and the powder damaged their machinery. The best packaging at present is therefore in gelatin capsules, although this will probably be changed shortly to a heat-sealed plastic strip.

Clinical data reported by the Canadian Dental Corps

The Canadian Dental Corps report that their present standard treatment for all cases of Vincent's infection is to give the patient 4 oz. of the present solution, with instructions to keep about 1 teaspoonful in the mouth for 2 minutes four times daily, making efforts to make it reach all crevices, the patient being allowed to spit out all solution, but not rinse the mouth. On the third day following, the patient is instructed to report back for corrective treatment.

The results- differing from previous treatments - are reported as singularly uniform, and may be summarized:-

Tissue loss is arrested immediately by the treatment even in severe necrotic cases.

"S-3"

Pain ceases 8 hours after starting treatment, although of course in severely inflamed areas discomfort naturally persists, but patients unable to eat due to swollen gums almost covering the teeth, can eat normally within 24 hours.

On the third day no evidence of active infection remains, inflamed areas have shrunk to normal size, and general oral correction is instituted, during which time the patient is given another 4 oz. of the treatment solution. This is done simply as a prophylactic measure, as a toothbrush cannot be used when all sites of infection are "packed", as very few patients actually require treatment longer than the three days.

It is interesting to note that Vincent's infection in the form of multiple oral ulceration has also been treated very successfully with this solution, and in several cases. Vincent's infection of the tonsils.

Toxicity of this Treatment

Since this treatment contains a small amount of arsenic (8 times less than Fowler's solution) it was necessary to consider any possible toxic effects of the treatments. Since the literature on the toxicity of arsenates is quite inadequate, a fairly extensive study was made of toxicity of arsenic with rats, guinea pigs, rabbits and cats. This need not be given in detail, but the results in synopsis are:-

Pentavalent, inorganic arsenates are about 5 or 6 times less toxic than are the trivalent, inorganic arsenites (the usual "arsenic") on the basis of the arsenic content of each preparation.

The treatment solution is therefore about 40 times less toxic than is Fowler's solution.

Furthermore, if even small amounts of the treatment are swallowed it produces vomiting due to its H_2O_2 content.

It is probable that a whole bottle (4 oz.) of the treatment could be taken daily for several weeks before serious symptoms would be produced, and to reach LD_{50} in a single dose would require 16 oz. of the solution to be taken (and retained) at one time. Very few effective medicinal preparations are of less toxicity.

Contrary to ordinary arsenic the arsenate in this treatment is eliminated very rapidly from the animal body.

The type of body damage caused by large amounts of arsenates is of such a nature that even if animals are seriously poisoned with it, they recover promptly if dosing is stopped.

This form of arsenate also does not produce blood shifts, diarrhoea or damage the gastro-intestinal tract as do the arsenites.

From the above it is clear that there can be no objection to this treatment from the toxicity viewpoint. It has in fact been used in Canada in excess of 60,000 treatments, and in its first form as predissolved separate solutions, throughout the world on an unknown but very large number of patients, without so far as is known any case showing a reaction attributable to arsenic. The well known sensitivity to peroxide is however met fairly frequently, and in such cases this ingredient is diluted more before adding the salts.

Pharmacology of this Treatment

There would appear to be several well defined reasons why this treatment is more effective than others.

Trivalent, or ordinary, arsenic is very readily precipitated on all protein materials, fundamentally as a sulphide, attached to the essential sulphur amino acid groups. This effect has three consequences: the arsenic damages the protein and is therefore an acute poison to all animal protoplasm; at the same time this form of arsenic is therefore unable to diffuse through protein material, as it is adsorbed on it; and as a further result small doses are cumulative and are removed from the body very slowly.

On the other hand, the pentavalent arsenate in this treatment is not adsorbed by protein in this way, since it forms sulphides only with difficulty. None of the above therefore applies to this form of arsenic; it is able to penetrate the tissue readily, and being an ion, it is absorbed readily by mucous membranes. However although relatively non-toxic to the patient, the spirochaete being anaerobic reduces all arsenate which it absorbs to the arsenite within the organism. In this form it is more or less permanently adsorbed in the organism and it continues to accumulate arsenic in this way until it acquires a lethal amount.

The simultaneous use of peroxide and a foaming agent with this arsenate of course also assists in speeding up the treatment, since the effervescence insinuates the solution into every crevice and pocket, and the foam produced also helps materially in lifting debris and leaving the pocket

"S-5"

open to continued treatment and also prevents the production of closed areas in which anaerobic conditions might persist.

It is understood that many dentists are now using this treatment, in its first form, in preference to others, but it is hoped that it will soon be available in its final form for general use.

Reports C310-45S, C7-47P, and C8-47S give the above results in detail.

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Division of Chemistry,
National Research Council.

October, 1947.

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